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Part III

Environmental Protection Agency

Benzene Emissions From Maleic Anhydride Plants; National Emission Standard

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 61

[FRL 1376]

National Emission Standard for Hazardous Air Pollutants; Benzene Emissions From Maleic Anhydride Plants

AGENCY: Environmental Protection Agency (EPA).

ACTION: Proposed rule and notice of public hearing.

SUMMARY: The proposed standard would limit benzene emissions from maleic anhydride plants. Emissions from existing sources would have to be reduced to 0.30 kilogram of benzene per 100 lilograms of benzene fed to the reactor. No detectable benzene emissions would be allowed from new sources. this can be done by substituting another feedstock, such as n-butane, for benzene. Benzene emissions during a control system malfunction could not exceed those that would occur if the benzene feed were shut off to all reactors as soon as practicable after the malfunction began. A new test Method 110 is proposed for the determination of benzene emissions from stationary sources.

The proposed standard implements the Clean Air Act and is based on the Administrator's determination of June 8, 1977, that benzene presents a significant carcinogenic risk to human health as a result of air emissions from one or more stationary source categories and is therefore a hazardous air pollutant. The intent of the standard is to protect the public health with an ample margin of safety.

A public hearing will be held to provide interested persons an opportunity for oral presentation of data, views, or arguments concerning both the listing of benzene as a hazardous air pollutant, which affects all benzene-emitting stationary sources, and the proposed standard for maleic anhydride plants.

DATES: *Comments.* Comments must be received on or before June 17, 1980.

Public Hearing. A public hearing will be held on May 20, 1980 beginning at 9:00 a.m.

Request to Speak at Hearing. Persons wishing to present oral testimony must contact EPA by May 13, 1980.

ADDRESSES: *Comments.* Comments on the health effects of benzene and the listing of benzene as a hazardous air pollutant should be submitted (in duplicate, if possible) to: Central Docket Section (A–130), Attention: Docket No. OAQPS 79–3, Part I, U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460. Comments on the proposed maleic anhydride standard should be submitted to: Central Docket Section (A–130), Attention: Docket No. OAQPS 79–3, Part II, same address.

Public Hearing. The public hearing will be held at Olde Colony Motor Lodge North Washington and 1st St., Alexandria, Va. Persons wishing to present oral testimony should notify Ms. Shirley Tabler, Standards Development Branch (MD–13), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, telephone number (919) 541–5421.

Background Information Document. The background information documents for the proposed standard are contained in the docket and may be obtained from the U.S. EPA library (MD–35), Research Triangle Park, North Carolina 27711, telephone number (919) 541–2777. Please refer to *Benzene Emissions from Maleic Anhydride Plants—Background Information Document for Proposed Standard (EPA–450/3–80–001a), Assessment of Health Effects of Benzene Germane to Low Level Exposures, Assessment of Human Exposures to Atmospheric Benzene,* and *Carcinogen Assessment Group's Report on Population Risk to Ambient Benzene Exposures.*

Docket. Docket No. OAQPS 79–3, Parts I and II, containing supporting information used in developing the proposed standard, is available for public inspection and copying between 8:00 a.m. and 4:00 p.m., Monday through Friday, at EPA's Central Docket Section, Room 2903B, Waterside Mall, 401 M Street SW., Washington, D.C. 20460. A reasonable fee may be charged for copying.

FOR FURTHER INFORMATION CONTACT: Mr. Don R. Goodwin, Director, Emission Standards and Engineering Division (MD–13), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, telephone number (919) 541–5271.

Supplementary Information

Notice is hereby given that under the authority of Section 112(b)(1)(B) of the Clean Air Act, as amended, the Administrator is proposing a national emission standard for benzene emissions from maleic anhydride plants. The proposed standard is consistent with EPA's proposed *Policy and Procedures for Identifying, Assessing, and Regulating Airborne Substances Posing a Risk of Cancer* (see 44 FR 58642). As prescribed by section 112(b)(1)(A) of the Act, the proposal of this standard was preceded by the Administrator's determination that benzene is a hazardous air pollutant as defined in section 112(a)(1) of the Act. Accordingly, the Administrator revised the list of hazardous air pollutants on June 8, 1977 by adding benzene (42 FR 29332).

A Background Information Document has been prepared that contains information on the manufacture and processing of maleic anhydride, the available control technologies for benzene emissions, and an analysis of the environmental, energy, economic, and inflationary impacts of regulatory options. Information on the health effects of benzene is contained in documents prepared by or for EPA, entitled the *Assessment of Health Effects of Benzene Germane to Low Level Exposure,* the *Assessment of Human Exposures to Atmospheric Benzene,* and the *Carcinogen Assessment Group's Report on Population Risk to Ambient Benzene Exposures.* The information contained in these documents is summarized in this preamble. All references used for the information contained in the preamble can be found in one of the four documents.

Proposed Standard

The proposed standard would apply to all maleic anhydride production units that process more than 500 megagrams (550 tons) of maleic acid, maleic anhydride, or both per year.

The proposed standard would limit the quantity of benzene that could be discharged into the atmosphere from each maleic anhydride production unit for which construction commenced on or before April 18, 1980 to 0.30 kilogram of benzene per 100 kilograms (0.30 lb/100 lb) of benzene fed to the reactor(s). Any maleic anhydride production unit for which construction or modification commenced after April 18, 1980 would be limited to no detectable benzene emissions as measured with the proposed Test Method 110; this standard could be met by using a feedstock such as n-butane rather than benzene for making maleic anhydride.

For existing sources, emissions in excess of the numerical emission limit would not be allowed during routine startup and shutdown of a plant. Emissions in excess of the numerical emission limit that are caused by control system failures would be allowed only if the plant owner or operator demonstrated to the Administrator's satisfaction that the emissions were unavoidable. Equipment failures that

could have been prevented by proper design, operation, and maintenance would be considered avoidable. Emissions in excess of the numerical emission limit that are due to unavoidable control system failures could be no greater than the total uncontrolled mass emissions that would occur during a plant shutdown. Maleic anhydride plants using benzene as a feedstock would have to install continuous emission monitors for benzene and report the occurrence of emissions in excess of the numerical emission limit within 10 days of each occurrence.

Existing sources would have to comply with the standard within 90 days of its effective date, unless a waiver of compliance were obtained. A waiver of compliance could be granted by the Administrator for no more than 2 years from the promulgation date.

Summary of Health, Environmental, Energy, and Economic Impacts

The proposed standard would affect as many as eight existing plants that produce maleic acid, maleic anhydride, or both as an end product. The standard would also apply to one plant that produces maleic acid as an intermediate in the production of fumaric acid. Because EPA has only recently become aware of this plant, it is not included in the health, environmental, energy, and economic impacts discussed in this section, in the remainder of the preamble, or in the Background Information Document. This plant would be covered by the proposed standard, however, because available information indicates that there is no technical reason to exclude it. The process, emission sources, and appropriate control technology appear to be the same as for the other plants that produce maleic acid, maleic anhydride, or both as an end product. Information on this plant is being collected and will be included in the evaluations of health, environmental, energy, and economic impacts at the time of promulgation.

Because newly constructed or modified maleic anhydride production units could emit no detectable quantities of benzene, potential future benzene emissions from these sources would be prevented. No additional benzene health effects would result from the expansion of existing plants or the construction of new plants.

The proposed standard would require uncontrolled benzene emissions from existing maleic anhydride production units to be reduced by approximately 97 percent. The proposed standard would reduce nationwide benzene emissions from the plants that produce maleic anhydride as an end product when they are operating at full capacity from about 5,800 megagrams (6,400 tons) per year to 900 megagrams (990 tons) per year. As a result of this emission reduction, there would be an order of magnitude reduction in the estimated incidence of leukemia deaths for the 10 million people estimated to live within 20 kilometers (12.5 miles) of existing maleic anhydride plants.

A more significant health impact than reduction in incidence would be the reduction in risk to the most exposed individuals living near maleic anhydride plants. This risk reduction would occur because the magnitude of the incidence is a function of the number of people exposed and the level of control at various plants as well as the risk factor. In the case of maleic anhydride plants, there are only a few plants, many of which already have some controls. Thus, the greatest health benefit of the standard is for the population at highest risk; i.e., those people living close to one of the several uncontrolled plants. The risk to the most exposed group due to emissions from process vents occurs 500 meters (550 yards) from the average-sized plant, and the proposed standard would reduce it by two orders of magnitude. It is estimated that 4,000 people live within 500 meters and 2,000 people live within 100 meters (110 yards) of maleic anhydride plants. In addition, a reduction in other health effects associated with benzene exposure (such as cytopenia, aplastic anemia, and chromosomal aberrations) may be expected.

The control systems likely to be used to meet the standard (incineration or carbon adsorption) would also reduce emissions of other hydrocarbons that may be toxic and that contribute to oxidant formation and associated environmental problems. Furthermore, if incineration were used, carbon monoxide emissions would be reduced.

The reduction in national benzene emissions achieved with the proposed standard would be obtained with minimal adverse impacts on other aspects of the environment. These adverse impacts could include small increases in nitrogen oxide and sulfur oxide emissions into the air. There could be small increases in solid wastes and benzene in wastewater. Compliance with the proposed standard would increase national energy consumption by an estimated 310,000 gigajoules (GJ/yr) (50,000 barrels of fuel oil equivalent per year) by 1980.

The capital investment required by the domestic maleic anhydride industry to comply with the proposed standard would be about $6.6 million over the 2-year period from 1978 to 1980. The total annualized costs of the industry due to control system installation would increase by about $2.5 million per year by 1983, and maleic anhydride prices would increase overall by about 1.2 percent. In addition, during control system malfunctions, production levels may be decreased to achieve compliance with the standard. This could cause between 15 and 42 hours of lost production per year. For a typical plant with an annual capacity of 22,700 megagrams (50,000,000 pounds), there would be an estimated cost of $1,000 to $1,500 per hour of lost production. The costs of foregone production are difficult tc quantify for the entire industry due to variations in plant design and operation and in market parameters. Furthermore, the proposed standard may result in one plant closure.

Rationale for Regulating Benzene Emissions Under the Authority of Section 112 of the Clean Air Act

Several activities by Federal agencies and a number of recent studies have increased public concern about exposure to benzene via inhalation. In September of 1976 and again in December of 1976, the National Institute for Occupational Safety and Health (NIOSH) recommended to the Occupational Safety and Health Administration (OSHA) that the Federal occupational exposure limit for benzene be reduced from a 10 parts per million (ppm) level for an 8-hour workday to 1 ppm. In January of 1977, OSHA issued nonenforceable guidelines to industry urging compliance with the NIOSH recommendations. In May, following receipt of a NIOSH study demonstrating that workers exposed to benzene are at considerable risk to leukemia, OSHA issued a temporary emergency standard that reduced the occupational limit from 10 to 1 ppm for an 8-hour daily exposure, OSHA promulgated that standard on February 10, 1978.

Following these actions by OSHA and NIOSH and in response to a petition from the Environmental Defense Fund (EDF), the Administrator announced in the June 8, 1977 **Federal Register** (42 FR 29332) his decision to list benzene as a hazardous air pollutant under Section 112 of the Clean Air Act. A "hazardous air pollutant" is defined as an ". . . air pollutant to which no ambient air quality standard is applicable and which . . . may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness."

Numerous occupational studies conducted over the past 50 years

provide evidence of health hazards resulting from prolonged inhalation exposure to benzene. Benzene has been recognized since 1900 as a toxic substance capable of causing acute and chronic effects. Benzene attacks the hematopoietic system, especially the bone marrow, and its toxicity is manifested primarily by alterations in the level of the formed elements in the circulating blood (red cells, white cells, and platelets). The degree of severity ranges from mild and transient episodes to severe and fatal disorders. The mechanism by which benzene produces its toxic effects, although under investigation, is still unknown.

The adverse effects on the blood-forming tissues, including leukemia, have been documented in studies of workers in a variety of industries and occupations, including the manufacture or processing of rubber, shoes, rotogravure, paints, chemicals and, more recently, natural rubber cast film. These studies include single-case reports, cross-sectional studies, and retrospective studies of morbidity and mortality among a defined cohort of workers industrially exposed to benzene.

Based on a review of the entire set of studies taken as a whole, the Administrator concluded that benzene exposure is causally related to the induction of a number of blood disorders including leukemia (a cancer of the blood-forming system).* Although the studies which form the basis for this conclusion involve occupational exposure to benzene at levels higher than those found in the ambient air, the Administrator has "made a generic determination that, in view of the existing state of scientific knowledge, prudent public health policy requires that carcinogens be considered for regulatory purposes to pose some finite risk of cancer at any exposure level above zero" (44 FR 58646). Based on its widespread use, emissions of benzene into the ambient air have been determined to result in significant human exposure. For these reasons benzene emissions may reasonbly be anticipated to result in one or more serious effects that can be expected to lead to an increase in mortality or an increase in serious, irreversible or incapacitating, reversible illness. Therefore, the Administrator concluded that benzene satisfies the definition of "hazardous air pollutant" under Section 112 of the Clean Air Act.

* Benzene has also been shown to be causally related to various cytopenias (decreased levels of a formed element in the circulating blood), aplastic anemia (a nonfunctioning bone marrow), and potentially inheritable chromosomal aberrations.

The Administrator considered the alternative of taking no further action and relying instead on the OSHA standard for benzene and volatile organic compound (VOC) control under the State Implementation Plans (SIP's). Reliance on the OSHA standard was rejected because the current OSHA standard stipulates a level of benzene that cannot be exceeded in the work place. This work place standard is not expected to result in the control of emissions from stacks within maleic anhydride plants, such as those for the product recovery absorber and refining system.

VOC emissions, as potential precursors of photochemical oxidants, are now being regulated under State Implementation Plans (SIP's). The goal of SIP regulations for VOC's is to effect statewide compliance with the National Ambient Air Quality Standard (NAAQS) for photochemical oxidants. Because benzene is a VOC, SIP regulations for reducing VOC's from maleic anhydride plants would also reduce benzene emissions. However, a particular State may not need to control maleic anhydride plants to meet that standard or it may not need to control VOC's to the same extend as may be appropriate for benzene in light of its hazardous nature. Consequently, the Administrator rejected reliance on SIP's for control of benzene emissions from maleic anhydride plants.

Furthermore, use of the Toxic Substances Control Act was rejected as a mechanism for controlling benzene emissions from maleic anhydride plants because the Clean Air Act provides a more direct, expeditious route for regulating these sources. The Toxic Substances Control Act could be used, however, as a possible mechanism for placing a maximum limit on the amount of benzene in gasoline and for regulating benzene levels in solvents.

Selection of Maleic Anhydride Plants for Regulation

Benzene is emitted from mobile sources, the gasoline marketing system, chemcial manufacturing plants, petroleum refineries, coke byproduct plants, benzene storage and handling, and chemical plant fugitive emission sources. Of all benzene emissions, currently 80 percent of the nationwide benzene emissions are estimated to be from mobile sources and 20 percent from stationary sources. However, only stationary sources are subject to regulation under Section 112 of the Clean Air Act. Therefore, while benzene emissions from mobil sources are of concern from an agencywide regulatory standpoint, the proposed standards for maleic anhydride plants were developed as a result of establishing priorities for the stationary sources above.

Maleic anhydride process vents were selected as a stationary source category of benzene emissions for regulation for a combination of two reasons. First, maleic anhydride plants account for 35 percent of all stationary source emissions of benzene and are by far the largest source of benzene emissions in the chemical manufacturing industry. Second, estimates of cancer incidence and risk to the most exposed population have been calculated for stationary source categories of benzene emissions. All these source categories were then ranked from high to low, first for incidence and then for risk to the most exposed population. When both incidence and risk were weighed together, maleic anhydride process vents ranked as one of the higher priority source categories for regulation.

Selection of Sources Within Maleic Anhydride Plants to be Regulated

Maleic anhydride is produced primarily by benzene oxidation and to a lesser extent by n-butane oxidation. A small amount is also recovered as a byproduct from phthalic anhydride manufacture. Benzene is not used in the n-butane oxidation process or in phthalic anhydride manufacture and is not believed to be emitted to the atmosphere from these processes. The standard technically applies to all maleic anhydride plants. However, because no benzene is believed to be emitted from sources that do not use benzene as a feedstock, these source are not subject to the testing, continuous monitoring, or excess emissions reporting requirements included in the standard.

The proposed standard would apply to plants that produce maleic acid, maleic anhydride, or both as an intermediate, as well as to plants that produce maleic acid, maleic anhydride, or both as an end product. The economic and environmental impact analyses for the proposed standard include only those plants that produce maleic acid, maleic anhydride, or both as an end product because EPA only recently learned about the existence of one plant that produces maleic acid as an intermediate in the manufacture of fumaric acid. Although the plant was not included in the assessment of the environmental and economic impacts of the proposed standard, it is covered by the proposal because available information indicates that there is no technical reason to exclude it. The process, emission sources, and appropriate control technology appear

to be the same as for the other plants that produce maleic acid, maleic anhydride, or both as an end product. This plant will be included in the assessment of the impacts of the standard at the time of promulgation.

The sources of potential benzene emission to the atmosphere from plants using the benzene oxidation process and the quantity of benzene each emits at an average or model plant (producing 22,700 Mg/yr [50,000,000 lb/yr] of maleic anhydride) are:

Source	Emission rate	
	(kg/hr)	(lb/hr)
Product recovery absorber	190	420
Refining system	(1)	(1)
Storage and handling	1.8	4
Fugitive	0.8	1.8

[1] Undetermined

(These emission rates are based on the industry average benzene conversion rate in the reactor of 94.5 percent.)

The proposed standard would cover the maleic anhydride production unit, which includes the reactor; the product recovery absorber, which emits over 98 percent of the benzene emissions; and the refining system. The product recovery absorber consists of equipment in which a gas stream from the reactor containing maleic anhydride or maleic acid is contacted with an absorbent liquid to recover the maleic anhydride, maleic acid, or both as a mixture. The refining system consists of equipment used to keep refining columns, single- or multiple-effect evaporators, crystallizers, and other unit separation process equipment under negative pressure. The refining system emits only small quantities of benzene; however, because if has a small flow rate, it can easily be controlled by the same control device used for the product recovery absorber with minimal additional expense.

Fugitive, secondary, and storage and handling benzene emissions are being considered for regulation by generic benzene standards. These generic benzene standards would apply to a large number of similar chemical industries and processes that emit benzene. This approach would be taken to reduce the number of standards required to cover essentially the same benzene emission sources in several different industries. Consequently, fugitive, secondary, and storage and handling emissions are not covered in this standard.

The proposed standard would cover any facility that uses benzene to manufacture at least 500 megagrams (550 tons) of maleic acid, maleic anhydride, or both annually. This number was picked as a cutoff to differentiate between commercial-sized plants and laboratory facilities. Existing commercial-sized plants produce more than 500 megagrams (550 tons) each year.

Selection of Regulatory Options

Three alternative emission control techniques were examined for maleic anhydride plants. The first of these techniques, conversion to n-butane as the feedstock, represents the use of a substitute. The other two alternatives, control of benzene by recovery or oxidation through the use of carbon adsorption or incineration, represent add-on controls.

The n-butane oxidation process uses n-butane in place of benzene as the feedstock in producing maleic anhydride. Because the process is believed to have no benzene emissions, conversion of benzene-based plants to use n-butane as the feedstock can be considered a control technique that potentially eliminates benzene emissions. The benzene and n-butane processes appear similar. In both processes, the feedstock enters a reactor where it is oxidized with the aid of a catalyst to curde maleic anhydride, which is then passed through a series of refining columns and collected as a finished product. Conversion to n-butane as a feedstock would require at a minimum the installation of a different catalyst and the installation of new feedstock storage tanks where n-butane can be kept as a liquid under pressure or as a refrigerated liquid at atmospheric pressure. Little information is available, however, to indicate what, if any, other process changes might also be required or what their impacts would be.

Carbon adsorption and incineration can achieve various levels of control, depending on the design and operation of the devices. Factors influencing the efficiency of carbon adsorption systems for benzene control at maleic anhydride plants include: (1) the relative humidity of the incoming waste gas stream, (2) the presence of other organic compounds that may interfere with benzene adsorption or that may form polymeric materials on the carbon beds, (3) the temperature of the beds during adsorption, (4) the efficiency of the steam regeneration, (5) the dryness of the bed, (6) the carbon bed size, (7) the number of beds, and (8) the cycle time. A well-designed carbon adsorption unit at a maleic anhydride plant should have a preheater to lower the relative humidity of the incoming gases since they are normally saturated with water and should use a caustic scrubber for removing most of the other organics in the gases. After regeneration, the carbon bed, which is hot and saturated with water, should be cooled and dried by blowing organic-free air through it. The cooling air should be recycled to the carbon adsorption system. The bed size, number of beds, and cycle times can be varied to achieve the desired removal efficiency.

Two maleic anhydride plants currently use carbon adsorption. The system at one maleic anhydride plant for which data are available is reported to achieve a benzene removal efficiency ranging from 85 to 95 percent. This system does not use an organic-free air stream to cool and dry the beds after regeneration with steam. Immediately after regeneration, the waste gas stream containing benzene is directed to the hot bed. Consequently, until the bed cools and dries, benzene removal efficiency is low. This partially accounts for the relatively low overall benzene removal efficiency.

Factors influencing the efficiency of an incinerator are temperature, degree of mixing, and residence time in the combustion chamber. For maleic anhydride plants, a knockout demister tank is required ahead of the incinerator to prevent entrained liquid droplets from reaching the burner area. Supplemental fuel is required to maintain the necessary combustion temperature. Supplemental combustion air may also be required, if the incoming gas stream is not preheated. A temperature of 870° C (1,600°F) is required to ensure complete combustion of the waste gas, although it is possible that greater than 99 percent benzene removal can be obtained at lower temperatures in some cases.

Two maleic anhydride plants in the United States that use benzene as a feedstock control the product recovery absorber emissions with combusiton. The first plant routes the waste gas stream from the product recovery absorber through a waste heat boiler. This system is reported by the plant's owner to achieve a benezene removal efficiency as high as 99 percent. The combustion temperature is about 1,090° C (2,000° F), and the residence time is 0.6 second. A waste heat boiler, however, is only a viable control technique when there is a need for the additional steam. Maleic anhydride plants generally produce a surplus of steam.

The second plant controls the product recovery abosorber waste gas stream with a thermal incinerator that operates at 760° C (1,400°F) and has a residence time of 0.7 second. Emission test data indicate that a sustained benzene

removal efficiency of about 97 percent is achievable.

Engineering experience with similar applications for the control of volatile organic chemicals indicates that a thermal incinerator can be designed and operated with a benzene removal efficiency of greater than 99 percent. Limited information is available concerning direct-flame afterburners used on maleic anhydride production facilities, but there are several cases in which streams similar to the product recovery absorber and refining system vent gas have been controlled at very high efficiencies. In one case, data reported for toluene indicate a removal efficiency of 99.9 percent at 766° C (1,410° F) and a residence time of 0.21 second. A second facility incinerates a toluene-xylene fume at 760° C (1,400° F) and is reported to achieve a destruction efficiency of 99.1 percent. A third installation also reports a removal efficiency greater than 99.8 percent at 760° C (1,400° F) for an organic stream considered as toluene. In addition, a review of several studies of incinerators indicates that combustion efficiencies less than 95 percent were achieved, except in one case, at temperatures of 730° C (1,350° F) or lower. Conversely, efficiencies greater than 99 percent were achieved at temperatures of 760° C (1,400° F) or higher.

Finally, recent laboratory studies on the thermal incineration of benzene show high benzene destruction efficiencies, which depend on temperature. Instrumentation with a benzene detection limit of two parts per millon by volume (ppmv) showed no residual benzene in gas streams following incineration at temperatures above 790° C (1,450° F) with residence times as low as 0.08 second.

The available information from the preceding paragraphs indicates that a conservatively designed and well-operated incinerator would be expected to consistently achieve at least 99 percent control of benzene at an operating temperature of about 870° C (1,600° F) and a residence time of 0.5 second.

These three emission control techniques for reducing benzene emissions from maleic anhydride plants lead to the following regulatory options:

(1) 97 percent benezene control, based on the best demonstrated level of control that is now being achieved at an existing maleic anhydride plant and that is universally applicable to any existing plant;

(2) 99 percent benzene control, based on technology transfer; and

(3) No detectable benzene emissions, based on conversion to n-butane as a feedstock.

Little information is available on what would be required to convert each existing benzene-based plant to an n-butane-based plant, or what the consequences of such a conversion would be. Based on the limited informaiton available, it appears that considerable effort continues to be directed towards developing n-butane technology, particularly the catalyst. Only the existing Amoco plant was originally designed to use n-butane as a feedstock. Problems associated with converting existing plants to n-butane include: (1) potentially signficant reductions in maleic anhydride production when current n-butane catalyst technology is combined with equipment designed for benzene as the feed stock, and (2) unsatisfactory operation resulting from equipment changes needed in the refining system. Because of uncertainties concerning the feasibility of converting each existing source to n-butane and the impacts of such conversion, this approach is not considered a viable regulatory option for existing sources based on best available technology (considering environmental, energy, and economic impacts) (BAT).

The use of n-butane as a feedstock, however, is considered a viable regulatory option for new sources. Because the industry was operating at only 56 percent of capacity in 1978, few new sources are expected to be built until the mid-1980's. This allows time for continued development of the n-butane process. Furthermore, a new plant could be designed to use n-butane and would therefore not encounter the potential problems associated with conversion. In fact, one company has recently announced the construction of a new 45,400-Mg/yr (50,000 tons/yr) maleic anhydride plant based on their proprietary n-butane technology, which is scheduled for completion in early 1983.

In summary, only two of the three options outlined above were considered viable regulatory options that could serve as the basis for a standard for existing sources based on BAT. These two regulatory options are designated: Option 1, 97 percent benzene control, and Option 2, 99 percent benzene control. For new sources, a regulatory option of no detectable benzene emissions (100 percent control) is considered a viable option as the basis for a standard based on BAT.

Selection of Basis of Proposed Standard—Existing Sources

One should note that neither Option 1 nor Option 2 specifically requires the use of carbon adsorption or incineration for control of benzene emissions from existing sources, nor would conversion to n-butane specifically be required for new sources. However, these control techniques were found to be feasible and were used as the probable contol methods in estimating the environmental, energy, and economic impacts of the regulatory options. Environmental, energy, and economic impacts were determined from a baseline assuming some benzene control. The numbers calculated for nationwide impacts are based on the assumption that all existing plants that have been using benzene as a feedstock will continue to be in operation and will continue to use benzene as a feedstock. Recently, one of these plants had indicated that is closing at least temporarily, and two of the plants have indicated they are investigating the possibility of converting to n-butane. If these changes occur, the numbers presented here for nationwide impacts on emissions, energy, and economics would be reduced. The impacts are summarized as follows.

Environmental Impact

The maleic anhydride industry was operating at only 56 percent of capacity in 1978 but is expected to be operating at 100 percent of capacity by the end of 1982. As the maleic anhydride industry increases production from 56 to 100 percent, nationwide unregulated benzene emissions would increase from about 3,300 Mg/yr to 5,800 Mg/yr (3,630 tons/yr to 6,380 tons/yr) based on 8,000 hours of operation per year. The term "unregulated" refers to the current level of control of benzene emissions from maleic anhydride plants. Some of these plants now practice some benzene control both voluntarily and in compliance with other standards but are not yet regulated by a national emission standard.

Option 1 would reduce nationwide benzene emissions from the maleic anhydride industry operating at 56 percent of capacity to about 650 Mg/yr (720 tons/yr) and operating at full capacity to 940 Mg/yr (1,030 tons/yr). Option 2, the more stringent option, would reduce nationwide benzene emissions to 440 Mg/yr (480 tons/yr) at 56 percent of capacity and 490 Mg/yr (540 tons/yr) at full capacity.

For the purpose of comparing the environmental impacts associated with no standard, Option 1, and Option 2 for an individual maleic anhydride plant, a model plant (i.e., and average-sized plant with a capacity of 22,700 Mg/yr [25,000 tons/yr]) was used. The total uncontrolled benzene emissions from

the model plant—including the product recovery absorber; refining system; and fugitive, storage, and handling emission sources—are estimated to be 1,500 Mg/yr (1,650 tons/yr) at 56 percent of capacity and 2,800 Mg/yr (3,080 tons/yr) at full capacity. The total benzene emissions for the model plant under Option 1 are estimated to be 77 Mg/yr (85 tons/yr) when the plant is operating at 56 percent of capacity and 110 Mg/yr (120 tons/yr) when the plant is operating at 100 percent of capacity. The benzene emissions under Option 2 are estimated to be 46 Mg/yr (50 tons/yr) at 56 percent of capacity and 60 Mg/yr (66 tons/yr) at full capacity. The estimates for Options 1 and 2 assume that fugitive and storage emissions are uncontrolled.

A dispersion model was used to project ambient benzene concentrations attributable to uncontrolled emissions, emissions regulated to meet Option 1, and emissions regulated to meet Option 2. The projected maximum annual average benzene concentration for an uncontrolled model maleic anhydride plant occurred at a distance of 0.3 kilometer (330 yards) from the plant and was 0.01 ppmv. For either Option 1 or Option 2, the maximum benzene concentration occurred at 0.1 kilometer (110 yards) from the plant and was 0.006 ppmv under either option.

If an incinerator were used to comply with a standard based on either Option 1 or 2, it would emit nitrogen oxides (NO_x), less carbon monoxide (CO) than an uncontrolled plant, possibly some particulates, and sulfur oxides (SO_x). Under either option, emissions of NO_x are roughly estimated to be increased by about 10 Mg/yr (11 tons/yr) at a model maleic anhydride plant. If all plants were to install incinerators, nationwide emissions of NO_x would be increased by an estimated 65 Mg/yr (72 tons/yr). If an incinerator were used to control benzene, it would also control CO emissions from the process and their would be a net reduction rather than an increase in CO emissions.

It natural gas were used as the auxiliary fuel for incineration, the increase in particulate and SO_2 emissions would also be negligible. It is possible, however, that gas would be unavailable for incineration in some locations. In these locations, fuel oil could be used, and depending upon the type of fuel oil, there could be an increase in SO_2 and particulate emissions. Assuming, for example, a fuel oil of 0.3 percent by weight of sulfur were used, SO_2 emissions at a typical maleic anhydride plant would increase by about 5 Mg/yr (5.5 tons/yr) under Option 1 and about 15 Mg/yr (17 tons/yr) under Option 2. If all plants were to install incinerators burning fuel oil of this sulfur content, nationwide emissions of SO_2 would be increased by about 50 Mg/yr (55 tons/yr) under Option 1 and about 110 Mg/yr (120 tons/yr) under Option 2. These adverse air impacts are considered small in light of the alternative of unregulated benzene emissions.

Incineration does not lead to any wastewater effluents requiring disposal. Consequently, there would be no adverse water pollution impacts associated with a standard based on either Option 1 or 2, if incineration were used to comply with the standard.

A wastewater stream containing benzene is associated with using a carbon adsorption system. However, the organic load of the wastewater from carbon adsorption is less than 10 percent of the total organic liquid waste load from a model maleic anhydride plant. The wastewater stream from a carbon adsorption system could be recycled to the product recovery absorber or treated along with the other plant effluent since the organic liquid effluent from a carbon adsorber system is similar in character to the other waste liquid streams from the process. The organic liquid effluent resulting from the use of a carbon adsorption system is therefore estimated to have an insignificant incremental impact on water pollution.

Maleic anhydride plants typically have a wastewater treatment facility to handle process effluents containing organics. Benzene is biodegradable and could be handled in such a treatment plant. However, this wastewater could become a secondary source of benzene emissions, if the benzene were to evaporate to the atmosphere during treatment. If all the benzene were to evaporate, the benzene emissions from wastewater at a model plant would be about 40 Mg/yr (44 tons/yr). The possibility of regulating air emissions from wastewater treatment is scheduled for future study.

The only potential impact on solid waste disposal associated with either Option 1 or 2 is the handling of spent carbon from carbon adsorption systems. Typically, rather than being disposed of in a landfill, spent carbon is reclaimed and regenerated at special facilities. If, however, spent carbon were disposed of in a landfill, the amount of solid waste from this source would be about 7,400 kg/yr (3.4 tons/yr) and 7,600 kg/yr (3.5 tons/yr) from a model maleic anhydride plant using this control technique to achieve compliance with a standard based on Options 1 and 2, respectively. As mentioned previously, however, it is likely that the spent carbon would be reclaimed, and there would be no impact on solid waste disposal under their Option 1 or 2.

Energy Impact

Although process heaters are required at startup and during some operations, the heat released from the oxidation of benzene and other compounds in the reactor during normal operations produces a small energy surplus of about 15 kilojoules (kJ) per kilogram (6.5 Btu/lb) of maleic anhydride produced. For the model plant with a production capacity of 22,700 Mg/yr (25,000 tons/yr), the energy surplus would be about 340 gigajoules (GJ) (322,000 Btu) per year.

Carbon adsorption requires energy in the form of steam to desorb the benzene from the carbon and electrial energy for pumps and other equipment. The energy requirement for a model maleic anhydride plant using carbon adsorption to meet a standard based on Option 1 would be about 85,000 GJ/yr (80.6×10^6 Btu/yr) and to meet a standard based on Option 2, it would be about 90,000 GJ/yr (85.3×10^6 Btu/yr).

Thermal incineration requires energy directly as fuel. If a typical maleic anhydride plant used thermal incineration to meet a standard based on Option 1, the energy required would be about 45,000 GJ/yr (42.7×10^6 Btu/yr) and to meet Option 2, it would be about 95,000 GJ/yr (90.0×10^6 Btu/yr), assuming 50 percent heat recovery.

Assuming that half the existing maleic anhydride plants that required additional controls used carbon adsorption and that half used thermal incineration to comply with a standard based on Option 1, the impact of the standard would be an increase in national energy consumption of about 310,000 GJ/yr (293.8×10^6 Btu/yr). This is equivalent to about 50,000 barrels of fuel oil per year. The impact of a standard based on Option 2 under the same assumption would be an increase in national energy consumption of about 525,000 GJ/yr (497.6×10^6 Btu/yr). This equivalent to about 85,000 barrels of fuel oil per year. These impacts are considered small; compared to U.S. oil imports in 1978 of 3.0 billion barrels of oil, they are negligible.

Economic Impact

Control equipment costs were developed from a baseline of current controls. When costs were developed, it was assumed that existing control systems that are currently not meeting the level of the standard under Option 1 or Option 2 could not be upgraded and would have to be replaced with new

control systems. Capital cost estimates were also based on control equipment designed to handle the waste gases from the product recovery absorber and refining system when operating at full production capacity. Cost estimates are considered accurate to ±30 percent.

For a model uncontrolled maleic anhydride plant with a capacity of 22,700 Mg/yr (25,000 tons/yr), compliance with a standard based on Option 1 would require a capital cost between $1.16 and $1.40 million, and compliance with a standard based on Option 2 would require a capital cost of about $1.22 to $1.44 million. The range in these estimates reflects the difference between using carbon adsorption and incineration as the control technique. These costs would increase the total capital expenditures of the average company that manufactures maleic anhydride by less than 1 percent. However, it should be noted that maleic anhydride sales generally represent less than 1 percent of the total sales for the average company that manufactures maleic anhydride.

Total annualized costs would be increased by about $354,000 to $442,000 per year for the model plant meeting a standard based on Option 1, depending on whether incineration or carbon adsorption were used as the control technique. If these costs were passed forward completely, the price of maleic anhydride would increase by about 1.2 percent, assuming current price levels and operation at 100 percent capacity.

Total annualized costs would be increased by about $369,000 to $600,000 per year for the model plant meeting a standard based on Option 2, depending on whether incineration or carbon adsorption were used as the control technique. If these costs were passed forward completely, the price of maleic anhydride would increase by about 1.7 percent, assuming current price levels and operation at 100 percent capacity.

In terms of national impact, Option 1 would require five plants to install controls. Total nationwide capital costs would be about $6.6 million. Option 2 would require at least seven plants to install control systems. Total nationwide capital costs under Option 2 would be about $9.1 million.

The increase in the industry's total annualized cost, assuming continued operation at 56 percent of capacity, would be about $2.2 million per year under Option 1 and about $3.9 million per year under Option 2. Assuming operation at 100 percent of capacity, total annualized industry cost would be increased by about $2.5 million per year under Option 1 and about $4.5 million per year under Option 2.

The impact of a benzene standard on the price of maleic anhydride would depend on at least two factors: (1) the percentage of capacity at which the industry is operating, and (2) the variation among companies with regard to price increases needed to fully pass through control costs.

In 1978, the industry was operating at 56 percent of capacity, and supply was substantially greater than demand. It is expected that demand will equal present listed capacity by the end of 1982 or sooner. The increased demand could reduce the competitiveness within the industry and allow maleic anhydride prices to increase to pay for control costs. Because controls to meet the standard would not have to be in operation before at least January of 1981, the potential price increases presented here are based on 100 percent utilization of listed capacity.

The price increase needed to fully pass through control costs varies from plant to plant. The estimated price increases presented here for Options 1 and are averages of the price increases that would be necessary for all the companies to fully recover their costs. This means that these estimated price increases would allow some companies to fully recover their control costs but would require other companies to absorb some of the costs. Companies that do not use benzene to make maleic anhydride or that already have control systems that would meet an option would incur no control costs and would not need a price increase. When the price increases for maleic anhydride were estimated, consideration was given to these plants with little or no control cost by averaging the price increases they would need to recover costs in with the price increases needed by the other companies.

Based on the assumptions discussed above, maleic anhydride prices would be expected to increase from a list price of 88¢/kg (40¢/lb) by about 1.2 percent if the standard were based on Option 1 and by about 1.7 percent if the standard were based on Option 2. There are two reasons for the differences in these estimated price increases. First, the cost of a control device to meet Option 2 is greater than for a control device designed to meet Option 1. Second, fewer plants would have to install controls to meet a standard based on Option 1 as opposed to Option 2.

Maleic anhydride is used in the manufacture of polyester resins, fumaric acid, and malathion. Any price increase in maleic anhydride is expected to be reflected in the price of these goods.

Based on an evaluation by EPA, one plant may close due to control costs regardless of the level of control selected as the basis for the standard. Based on conversations with representatives from another company and an independent evaluation by EPA, a second plant could close because of control costs if the standard is based on 99 percent control. Because this plant already has an incinerator that can attain 97 percent control, it would not cease to manufacture maleic anhydride if the standard is based on that control level.

This company expressed concern that, for a combination of reasons, it could not finance the control system that it would need at the 99-percent control level. One reason is that it could not pass through all the costs of control. The fact that the industry is expected to be operating at less than listed capacity when the company would need to begin making expenditures for control equipment would make it difficult to increase the price of maleic anhydride to compensate for those control costs. Furthermore, because this company has not been identified as a price leader, it may have to absorb some of the control costs even after the industry begins to operate closer to listed capacity. Also, the company is located in Texas and has to compete with imports of maleic anhydride from Mexico. A second reason the company probably cannot afford the controls is that within the last 4 years it has made a major capital outlay for the control device that meets the 97-percent control level, and it is still recovering from this investment. Furthermore, this company only makes two products, and maleic anhydride represents one-third of its sales. For other companies, maleic anhydride sales generally represent less than 1 percent of total sales. The product mix factor limits the ability of this company to use the profits from other operations to finance controls for the maleic anhydride plant.

This plant was originally designed to use 2-butene rather than benzene as the feedstock and has recently obtained a State permit to use n-butane. At least initially this company is planning to convert part of its capacity to n-butane on an experimental basis; it is uncertain whether it will convert to n-butane on a permanent basis. The company converted one reactor to n-butane on an experimental basis in 1975 and 1976 but converted back to benzene due to technical problems with the process and catalyst instability. If the plant did convert to n-butane on a permanent basis, it would not be affected by a benzene standard and would probably not close. If the plant could not

successfully convert to n-butane and the standard were based on 99 percent control, the plant might have to close.

If both of these maleic anhydride plants closed, approximately 50 employees could lose their jobs. If the plant projected to close at either control level were the only plant to close, about 20 employees could lose their jobs. Because these employees would be petrochemical workers and both plants are located in areas with numerous other petrochemical plants (Texas and New Jersey), it is possible they could find employment in the same areas. Also, one of the companies is very large and may be able to relocate the employees from the maleic anhydride plant within the company.

In summary, it is estimated that a standard based on 99 percent control would result in total capital costs of about $9.1 million, an increase in total annualized costs of about $4.5 million, a potential price increase in maleic anhydride of 1.7 percent, an increase in energy usage of 85,000 barrels (bbl) (525,000 GJ/yr or 497.6 $\times$ 10^6 Btu/yr of oil per year, and as many as two projected plant closures. A standard based on 97 percent control would result in total capital costs of about $6.6 million, an increase in total annualized costs of about $2.5 million, a potential price increase in maleic anhydride of 1.2 percent, an increase in energy usage of about 50,000 bbl (310,000 GJ/yr or 293.8 $\times$ 10^6 Btu/yr) of oil per year, and as many as one projected plant closure.

In selecting best available technology (considering environmental, energy, and economic impacts) (BAT), the Administrator examined the impacts discussed and arrived at the following conclusions. First, control in the range of 97 percent is the best demonstrated control that has been achieved at an existing maleic anhydride plant with a control system that is applicable to all other existing plants. Higher levels, such as 99 percent, are believed to be technically feasible, but only with technology transfer and at a higher cost and energy use. Second, one plant that is not projected to close if the standard were based on 97 percent control is projected to close at the 99-percent control level if it cannot successfully convert to n-butane. Based on these two considerations, the Administrator selected the 97-percent control option as BAT.

After the 97-percent option was identified as BAT for existing sources, the estimated risks remaining after application of BAT were examined to determine whether they are unreasonable in view of the health benefits and costs that would result if a more stringent option were applied. The number of estimated leukemia deaths remaining after application of BAT to existing sources is estimated to range from 0.03 to 0.19 per year.* Fifty percent of these residual deaths would result from fugitive, secondary, and storage and handling emissions, which will be considered for regulation at a later date. After application of BAT to existing sources, the remaining estimated maximum lifetime risk of acquiring leukemia is estimated to range from 5.8 $\times$ 10^{-5} to 41 $\times$ 10^{-5} for the most exposed group living around a model uncontrolled maleic anhydride plant. Fugitive emissions, which are not covered by the recommended standard, are the predominant contributors to these risks. Maximum lifetime risk is the probability of someone contracting leukemia who is exposed to the highest maximum annual average benzene concentration for a period of 70 years. Farther from the plant, where process vents are the predominant contributors to risks, a standard based on BAT for existing sources would result in an estimated residual maximum risk caused by emissions from process vents only from 0.5 $\times$ 10^{-5} to 3.5 $\times$ 10^{-5}.

The Administrator considered two control levels beyond BAT for existing sources: 99 percent control, and the use of a feedstock other than benzene in the manufacture of maleic anhydride (100 percent control). Requiring 99 percent control instead of 97 percent control would reduce the estimated incidence of leukemia deaths within 20 km of maleic anhydride plants from a range of 0.03 to 0.19 per year to a range of 0.02 to 0.14 per year. It would reduce the estimated maximum lifetime risk at the point of maximum exposure caused by emissions from the process vents from a range of 0.5 $\times$ 10^{-5} to 3.5 $\times$ 10^{-5} to a range of 0.1 $\times$ 10^{-5} to 1.0 $\times$ 10^{-5}, while the maximum lifetime risk caused by emissions from all sources within a plant would remain unchanged.

On the other hand, requiring 99 percent control rather than 97 percent control would increase the capital cost from $6.6 to $9.1 million, the total annualized cost from $2.5 to $4.5 million, and the percentage increase in maleic anhydride prices from 1.2 to 1.7. It would also result in as much as one additional projected plant closure.

Requiring the use of a feedstock other than benzene in the manufacture of maleic anhydride would decrease both the estimated incidence of leukemia cases and the estimated maximum lifetime risk to zero. As discussed previously, a great deal of uncertainty exists concerning the technological changes required to convert each existing source to an alternate feedstock and the resulting economic impacts.

In view of the relatively small health benefits that would be gained with the additional costs (including as many as one additional projected plant closure) of requiring 99 percent rather than 97 percent control for the process vents and the uncertain economic impacts if a substitute feedstock were required for existing maleic anhydride sources, the Administrator concluded that the risks remaining after application of BAT to existing sources are not unreasonable. Therefore, the Administrator decided not to require more stringent control than BAT for process vents. This decision does not preclude future regulation of fugitive, storage, and secondary emission sources, which are major contributors to the residual risk.

Selection of Basis of Proposed Standard—New Sources

Requiring 100 percent control based on the use of an alternative feedstock, such as n-butane, is considered to be a viable BAT option for new sources because some of the previously discussed problems associated with converting existing sources to n-butane would not be present. In considering this option, the Administrator examined the potential safety, environmental, and economic impacts of that action to the extent possible given limited information.

The use of n-butane would result in no significant changes in the safety of the process and would slightly increase the overall safety of maleic anhydride production. For example, a higher concentration of n-butane (as compared to benzene) is required for an explosion to occur. In addition, inhalation of and

*The ranges contained in this preamble represent the uncertainty due to estimates that had to be made concerning the levels of benzene to which workers were exposed in the Infante, Aksoy, and Ott studies that served as the basis for developing the benzene risk factor. The ranges are based on a 95-percent confidence interval that assumes the estimated concentrations to which the workers are exposed vary within a factor of two. In addition, there are other sources of uncertainty. The deaths were calculated based on extrapolation of leukemia risk associated with a healthy white male cohort of workers to the risk associated with the general population, which includes men, women, children, infants, the aged, nonwhites, and the unhealthy. Also, the number of deaths includes consideration of only one effect of benzene, leukemia. Benzene may cause aplastic anemia, cytopenias, and the development of chromosomal aberrations. In addition, the benefits to the general population of controlling other types of emissions from maleic anhydride manufacture have not been quantified. Furthermore, ambient benzene concentrations used to calculate the excess risks and deaths were derived from an atmospheric dispersion model with an error of a factor of two. Finally, there are inherent errors in estimating the population within 20 kilometers of existing plants.

exposure to n-butane by workers is less hazardous than exposure to benzene. n-Butane is already used as a feedstock for similar situations within the petrochemical industry.

There are two potentially adverse environmental impacts of requiring the use of n-butane in place of benzene as the feedstock for new sources. These include possible increased benzene emissions from gasoline marketing and increased volatile organic compound emissions. If eliminating benzene as a feedstock for new sources resulted in the addition of more benzene to gasoline, the incremental increase in total benzene emissions from gasoline marketing would be greater than if the benzene were used at a controlled maleic anhydride plant.

Because existing sources can continue to use benzene as a feedstock, only the benzene that would have been used at new sources would be of concern. Currently, benzene demand often exceeds the available supply; this situation is expected to continue through the 1980's. Consequently, the benzene that would be used at new sources, if there were no standard, is not currently being produced, and if new maleic anhydride plants wanted to use benzene as their feedstock, an increase in benzene demand would result.

Typically, when demand for benzene fluctuates, supply is adjusted by changing the level of production from the most expensive source. If benzene were not prohibited as a feedstock for new sources and there was little, if any, slack in the benzene supply, the additional benzene required would probably be supplied by toluene hydrodealkylation (HDA). HDA is the most expensive benzene production method and changes in benzene demand can be accommodated by changing the volume of benzene production from HDA. HDA production currently represents 25 to 30 percent of benzene production. Since existing maleic anhydride plants currently use 3 percent of the benzene produced, the HDA process should be able to accommodate fluctuations in demand for benzene caused by maleic anhydride producers.

If chemical process industries know that benzene will not be used as a feedstock for maleic anhydride production, they will presumably adjust their projections of future benzene demand. Additional benzene production capacity would be adjusted to reflect this decrease in demand for benzene as a feedstock for new maleic anhydride sources.

Thus, based on these considerations, it was concluded that the proposed standard would be unlikely to result in more benzene being added to the gasoline pool.

Although few data are available on the quantity and composition of the emissions of volatile organic compounds (VOC) from an n-butane-based plant, preliminary information indicates that total uncontrolled VOC emissions are higher than for a benzene-based plant. At present, there is no nationwide requirement to control the emissions from the n-butane oxidation process for maleic anhydride production. However, VOC emissions are currently controlled by State regulations where new n-butane-based plants are likely to be constructed. In addition, EPA is beginning work on a new source performance standard under Section 111 of the Clean Air Act for all air oxidation reactions in the organic chemical industry. This standard is anticipated to cover maleic anhydride production from n-butane.

The potential economic impacts of requiring n-butane include impacts on: (1) domestic licensors of n-butane and benzene technology, (2) availability and price of n-butane and benzene feedstocks, and (3) the economic life of existing maleic anhydride plants.

Only one domestic licensor of maleic anhydride technology exists. This licensor licenses both the benzene and n-butane processes. Abroad, there are five licensing companies. Of those five, only one licenses both benzene- and n-butane-based technology, while the other four solely license the benzene-based process. The U.S. licensor would probably maintain its foreign business because an EPA requirement would not affect usage of benzene-based technology abroad. However, the company's domestic business would depend on the competitive status of its n-butane catalysts at the time that benzene replacement is mandated. Because catalyst technology is usually a closely held company secret, the companies developing such catalysts and their rates of success with new catalysts have not been determined.

Use of n-butane as a feedstock can lead to as much as a 7.3¢ cost reduction per kilogram over benzene feedstock costs. This difference in feedstock costs is not expected to lessen in the next 10 years and may even increase. Supplies of n-butane are expected to exceed demand through 1990, while benzene demand will probably continue to exceed supply.

Requiring the use of n-butane for new sources would not affect the economic life of existing plants. Because of the cost advantage associated with using the n-butane feedstock, maleic anhydride manufacturers are likely to decide to use the n-butane process for new sources regardless of an EPA mandate to do so. For example, the only new maleic anhydride plant announced in recent years will be a 45,400-Mg/yr (50,000 tons/yr) plant based on proprietary n-butane technology. Construction is expected to be completed in 1983. Consequently, any impacts that occur on the economic life of existing plants from new plants using n-butane cannot be directly attributed to the EPA mandate.

In summary, the potential safety, environmental, and economic impacts associated with requiring new sources to use an alternative feedstock such as n-butane are minimal. Consequently, 100 percent control has been selected as BAT for new sources. Because this level of control is expected to result in no benzene emissions, it is not necessary to consider a level of control beyond BAT for new sources.

Excess Emissions

Because experience indicates that control systems are not 100 percent reliable, control system malfunctions and associated emissions in excess of the numerical emission limit for existing sources can be expected to occur at maleic anhydride plants. Even if a maleic anhydride source were shut down because of control system malfunction, there would still be emissions in excess of the level of the numerical emission limit during shutdown. For an average-sized plant with a capacity of 22,700 Mg/yr (25,000 tons/yr) and three reactors, it is estimated that 250 kilograms (550 pounds) of excess benzene emissions would occur during a controlled shutdown, assuming the plant is operating at the average benzene conversion rate of 94.5 percent. Although the benzene feed to a reactor could be stopped immediately, the benzene in the system would have to be purged to the atmosphere, which generally takes 15 to 20 minutes. Furthermore, if a plant had more than one reactor, the reactors would probably have to be shut down sequentially to avoid damaging the equipment. Most control system malfunctions at maleic anhydride plants can be repaired relatively quickly, within 12 hours at a maximum. Occasionally, a control system malfunction requiring extensive repair time can occur.

The Administrator considered four different regulatory options for the treatment of emissions in excess of the level of the numerical emission limit due to control system malfunctions at maleic anhydride plants: (1) allowing unlimited excess emissions, (2) requiring plants to

shut down during control system malfunctions or to have no more emissions than if they did shut down, (3) requiring installation of a flare, and (4) allowing no excess emissions (i.e., essentially requiring installation of a backup control system that is equally efficient to the primary control system). The Administrator considered options only for treatment of excess emissions during control equipment failures. He did not consider allowing excess emissions during routine startup or shutdown or during process equipment failures based on the judgment that the air pollution control equipment at maleic anhydride plants is capable of preventing excess emissions during these periods.

The Administrator eliminated Options (1) and (3) based on a preliminary analysis. Option 1, allowing unlimited uncontrolled emissions during control system malfunctions, could significantly increase total mass emissions per year. For example, one existing maleic anhydride plant has had a control system malfunction that took about a year to repair. Although such events are expected to be rare, allowing uncontrolled emissions of benzene from maleic anhydride plants for this period of time was not judged appropriate. The next most stringent option (i.e., requiring plants to shut down or have no more emissions than if they shut down), could result in lost production but does not appear to be economically prohibitive. Therefore, the option of allowing unlimited excess emissions during control system malfunctions was not analyzed further.

The option of requiring a flare during a control system malfunction at first appeared to be a desirable option because flares could achieve some emission reduction during malfunctions of primary control systems and yet are generally less expensive than control systems such as incinerators and carbon adsorbers. However, traditionally, flares have not been used on sources, such as maleic anhydride plants, which have high-volume, low-concentration exiting gas streams. The control efficiency is not known but is expected to be considerably less than that of an incinerator or carbon adsorber for a high-volume, low-concentration stream. In addition, considerable quantities of natural gas would be required to flare the dilute waste gas stream found at maleic anhydride plants. The waste gas stream contains about 98 kcal/m^3 (11 Btu per standard cubic foot [SCF]), which is well below the levels for efficient use of flares. Therefore, up to 19,800 m^3/hr (700,000 SCF/hr) of natural gas would be required to operate the flare. Also, the flare would need to be operated from 5 to 20 hours per month in order to ensure rapid startup during control system malfunctions and to maintain it in efficient operating condition. This would require additional energy. For these reasons, the use of a flare during control system malfunctions did not appear to be a desirable control option for sources such as maleic anhydryde plants, which have high-volume, low-concentration waste gas streams.

Consequently, two regulatory options were further analyzed: Option 2, requiring plants to shut down during control system malfunctions or to have no more emissions that if they did shut down; and Option 4, allowing no excess emissions.

In order to estimate the costs that would result from allowing excess emissions equal to uncontrolled shutdown emissions, data on the frequency and duration of control equipment failures at two maleic anhydride companies were obtained. One company uses incineration and the other uses carbon adsorption. The company with the incinerator has experienced about 15 relatively short-term control equipment failures a year. If the approach under consideration were implemented, this company's plant could be operated in a modified manner with a reduced production rate during most malfunctions and have no more emissions than if it were shut down. Possible costs include 15 to 42 hours of lost production per year. It is estimated that the net cost of lost production would be $1,000 to $1,500 per hour for a plant with a capacity of 22,700 Mg/yr (50,000 tons/yr). Whether the total annual production would actually be reduced because of such a regulation would depend on whether the plant was operating at less than full capacity and thus could compensate for the lost production. The probability of a malfunction requiring extended repairs and complete shutdown because of the proposed regulation appears small.

The company with the carbon adsorber has found that most control device failures affect only one of the three beds. Such failures can be handled by reducing feed rates and operating the remaining two beds normally while the affected bed is isolated and repaired. Complete control device failure usually takes only 1 to 4 hours to repair. Therefore, the only possible result of the option of allowing excess emissions equal to shutdown emissions for a plant with carbon adsorption is again possible reduced production.

Because of several factors, the total industry cost of lost production that may result if this option were implemented is difficult to quantify without doing a detailed plant-by-plant analysis. Ordinarily, plants do not operate at full capacity for extended periods of time due to market, maintenance, or other conditions. Consequently, the production foregone during the time required to repair the control system can, in many cases, be made up by increasing production rates after the repair is completed. The extent to which this can be done is expected to vary from plant to plant and from time to time within a plant. Other factors, such as the type of control system used, the design of the plant, the number of reactors within a plant, the use of the steam produced during maleic anhydride production, and the nature and extent of the control system malfunctions are expected to vary from plant to plant and will affect the magnitude of production revenue actually foregone for the entire industry.

However, if the option of allowing excess emissions equal to those of shutdown were adopted, the ensuing costs are anticipated to result in no additional plant closures. Also, because only production curtailment would be involved, energy impacts and negative environmental impacts would not increase in relation to normal operation.

For the option of allowing no excess emissions during control system malfunctions (i.e., essentially requiring backup control systems), the model plant would incur additional capital costs of about $900,000 and an increase in annualized costs of about $223,000 above those costs without backup. The total capital costs for the industry (for both a primary and backup control system) would be about $13.9 million, the total annualized costs would be about $4.4 million, and the maleic anhydride price would increase about 2.0 percent. Furthermore, the same plant, which already has a 97-percent efficient incinerator and which is projected to close if the standard were based on 99 percent control, is also projected to close if it were required to install a backup control system.

In selecting BAT, the Administrator first examined the option of allowing no excess emissions. This option would more than double the industrywide capital costs. The Administrator rejected this option as BAT because he considered the increase in capital costs grossly disproportionate to the emission reduction achieved and because the plant closure projected to occur if he selected it could be eliminated by

selecting the option of allowing excess emissions equal to those that would occur during shutdown. Because the impacts and costs of the option of not allowing excess emissions to exceed those that would occur during shutdown appear reasonable, he selected that option as BAT. This approach for selecting BAT for controlling excess emissions is similar to the approach used in determining BAT for continuous emissions. That is, it is based on the technologies and associated economic and environmental impacts specific to the source being regulated. Because the available technologies and associated impacts for controlling excess emissions from other sources regulated under Section 112 are likely to differ, it should not be assumed that BAT for controlling excess emissions from maleic anhydride plants will necessarily be applied to other sources.

In order to calculate the risks remaining after application of BAT to existing sources (i.e., a combination of 97 percent control during normal operation and allowing excess emissions during control system malfunctions equal to those during shutdown), the expected frequency of malfunctions was assumed to be 15 per year and the total quantity of uncontrolled emissions that would occur during shutdown was assumed to be 250 kilograms (550 pounds). A frequency of 15 malfunctions per year was selected for this analysis based on the data supplied by the plant with an incinerator. It is considered to be "worst case" because some of the control system breakdowns experienced by this company may have been avoidable and therefore would not be expected to occur if the proposed standard were in effect. Exposure estimates were obtained for the shutdown period and normal operation. The linear dose-response model was then used to calculate residual leukemia cases using both types of exposure.

The Administrator considered the possibility that when these short-term peak exposures, which may range up to 2.0 ppm for up to 3 hours duration, are mixed with chronic, relatively low exposures, the linear model may not provide conservative estimates of incidence and risk. This question arose because a recent study funded by the Consumer Product Safety Commission indicated that one exposure to a high level of vinyl chloride (another carcinogen regulated under Section 112) can result in a higher probability of cancer risk than the same dosage spread over a longer period of time. The exposure levels used in the vinly chloride study were much higher than benzene exposures that would occur around maleic anhydride plants during control system malfunctions. In addition, analysis of previous occupational benzene exposure studies—upon which calculations in the EPA *Carcinogen Assessment Group's Report on Population Risk to Ambient Benzene Exposures* are based—shows that, for benzene concentrations with a range of 0.2 ppm to 4.0 ppm, the lifetime probability of cancer is approximately proportional to the concentration. Consequently, the linear model is valid for the range of ambient benzene levels anticipated to occur during control system malfunctions, and there is no reason to expect that peak exposures of up to 2 ppm would have a higher level of cancer incidence per part-per-million year of exposure than lower continuous exposures. For these reasons, the Administrator has judged that the linear model can be expected to provide conservative estimates of incidence and risk at the exposure levels that would occur during control system malfunctions at maleic anhydride plants. For different pollutants or sources with different emission characteristics, this relationship may not hold, and short-term peak exposures may indeed cause a higher level of cancer than indicated by the linear model.

The number of leukemia deaths remaining after application of BAT (including the allowance for emissions in excess of the level of the numerical emission limit) to existing sources was estimated to range between 0.026 to 0.18 per year within 20 km of the sources. The maximum lifetime risk from exposure to all sources within a plant to the most exposed population was estimated to be 5.8×10^{-5} to 41×10^{-5} and, from exposure to the process vents only, it was estimated to be 0.50×10^{-5} to 3.5×10^{-5}.

The Administrator next analyzed the option of allowing no excess emissions during control system malfunctions; i.e., requiring a backup control system equal in efficiency to the primary control system as an option beyond BAT. Thus, there would be a reduction in the estimated number of leukemia deaths from a range of 0.026 to 0.18 per year to a range of 0.025 to 0.17 per year. The estimated maximum lifetime risk from exposure to emissions from the process vents and to emissions from all sources within the plant would remain unchanged.

Requiring a 97-percent efficient backup control system in addition to a 97-percent efficient primary control system would increase the capital costs from $6.5 million to $13.0 million, the total annualized cost from $2.5 million to $4.4 million, and the percentage increase in maleic anhydride prices from 1.2 to 2.0. It would also increase the number of potential plant closures from one to two. After weighing the costs and benefits of selecting this option, the Administrator determined that the residual risks after applying a standard to existing sources based on BAT for controlling excess emissions would not be unreasonable. Therefore, the proposed standard is based on this level of control.

To limit the frequency of excess emissions due to control system malfunctions, control system malfunction is defined in the proposed standard as "any sudden and unavoidable failure of air pollution control equipment." This places the burden on the plant owner or operator to prove that emissions in excess of the numerical emission limit were unavoidable; i.e., no emissions in excess of the numerical emission limit would be allowed unless the Administrator were satisfied that an unavoidable equipment failure had occurred. Failures caused entirely or in part by poor maintenance, careless operation, deficiencies in design, or any other preventable upset conditions or preventable equipment breakdown would not be considered malfunctions. Recurring patterns in air pollution control equipment failure may be considered indicative of preventable failures.

Section 61.93 of the proposed standard includes requirements for implementing this approach. These requirements would be implemented in the following manner: Section 61.10 of the General Provisions requires submittal of an initial report from each existing source describing the source and emissions; Section 61.93 of the proposed standard would require that the initial report include information necessary for determination of the total uncontrolled mass emissions during a controlled shutdown of a source. The required information would consist of a description of the shutdown procedure at each plant, including a step-by-step account, the time period required for each step, and the amount of emissions expected to occur during each step. Emissions would be calculated based on the assumption that the plant is operating at full capacity with no control device. Using information gathered during development of the standard, the Administrator would review the information submitted by the source owner or operator and approve or disapprove the shutdown emissions

included in the initial report as the allowable emission limit during a control system malfunction for that source. If a source changed in some way that affected shutdown emissions, the owner or operator would have to submit a second report and obtain approval for a revision in the allowable shutdown emissions for the source.

The proposed standard requires all sources that use benzene as a feedstock to install continuous monitoring systems. If the continuous monitor indicated that emissions had exceeded the numerical emission limit (averaged over three cycle times for carbon adsorbers or 3 hours for other control devices), these emissions would have to be reported to the Administrator within 10 days. If the owner or operator believed that the excess emissions resulted from an unavoidable failure of control equipment, he would state in the report that he believed the excess emissions were due to a control system malfunction. He would then include a description of the cause of the malfunction, the steps taken to remedy the malfunction, the steps taken or planned to prevent the recurrence of such a malfunction, documentation that the air pollution control or process equipment was at all times maintained and operated (to the maximum extent practicable) in a manner consistent with good practice for minimizing emissions, and any other evidence that the excess emissions were unavoidable. In addition, the owner or operator would be required to report the total mass of excess emissions and data documenting his calculation or measurements, including the duration of the control system malfunction as determined by flow meter measurements required under Section 61.95(a).

The Administrator would use the report and any other information requested or available to him to determine whether a malfunction had occurred. If the Administrator determined that a malfunction had occurred, he would use the information submitted to him and otherwise obtained to determine whether the total mass emissions exceeded those that would occur during a controlled shutdown (i.e., emissions that were calculated in conjunction with the initial report). The Administrator recognizes that, because the quantities of emissions that would occur during a controlled shutdown and during a control system malfunction and that would be reported to him would probably be calculated, they would not be as precise as if they were measured. If the Administrator determined that a malfunction did not occur and the emissions in excess of the numerical emission limit were measured with an emission test, the source would be considered in violation of the numerical emission limits in Section 61.92(a)(1). If, on the other hand, the Administrator determined that a malfunction did not occur and emissions in excess of the numerical emission limit were measured with a continuous monitoring system, the source would be considered in violation of Section 61.92(c). If the source exceeded the amount of excess emissions allowable under a controlled shutdown, it would be considered in violation of Section 61.92(b) or Section 61.92(c). Section 61.92(c) states that a source is to be operated in a manner consistent with good air pollution practice for minimizing emissions and that continuous monitoring data among other information can be used to determine whether that is the case.

Many times a plant may not be operating at capacity. In these situations, the actual emissions that would occur during a controlled shutdown of the plant would be less than those of the calculated controlled shutdown mass emission limit approved by the Administrator. This would allow the plant more emissions during a malfunction than would actually be emitted if the plant had an immediate controlled shutdown. However, for several reasons, operation at less than full capacity was not considered significant enough to warrant using less than 100 percent capacity as the basis for determining the controlled shutdown mass emission limit. The capacity at which a plant operates can fluctuate on a daily or even hourly basis depending on operational and market conditions. Consequently, the Administrator would be required to determine the plant's controlled shutdown mass emission limit every time a control equipment failure occurred.

In addition, one means of meeting the controlled shutdown mass emission limit would be for the plant to reduce its production rate. If the percent of capacity used to calculate the controlled shutdown mass emission limit were less than 100 percent, the extent to which the production rate could be reduced by the plant to comply with the mass emission limit would be severely limited. Consequently, if the plant were unable to use reduction in production rate as a means to comply with the mass emission limit during a control equipment failure, it might have to shut down completely. Because of technological and economic problems that could result if a plant frequently had to shut down completely, it might choose to install a backup control system. This option has been previously rejected as the standard. Therefore, the controlled shutdown mass emission limit is based on a plant operating at 100 percent capacity.

Selection of Designated Source

The designated source is the facility or grouping of facilities to which a standard applies. The proposed standard for maleic anhydride plants contains different emission limits for existing and new sources. An existing source is one for which construction is commenced on or before the date of proposal of the standard. A new source is one for which construction, modification, or reconstruction is commenced after the date of proposal of the standard. The manner in which the source is designated (i.e., the number of facilities included in the grouping) can affect whether or not a particular source is considered existing or new. Consequently, the manner in which the source is designated can influence the impacts of a standard. The Administrator considered these potential impacts in designating the source at maleic anhydride plants.

First he considered designating each different piece of equipment, such as a reactor, a product recovery adsorber, and a refining system, as a source. However, maleic anhydride and maleic acid are produced using an integrated combination of reactor(s), a product recovery absorber, and a refining system. Typically, these pieces of equipment are designed on an integrated basis for the use of a specific feedstock, such as benzene. Consequently, if a feedstock change is made, extensive changes may have to be made not only in a reactor but also in the product recovery absorber and refining system integrated with the reactor.

If each piece of equipment were designated as a source and a reactor had to be replaced, the reactor would have to use a feedstock other than benzene. In addition, if the associated product recovery absorber and refining system had been designed for the operational conditions associated with the use of benzene as a feedstock, changes might also have to be made to them to allow the use of a feedstock such as n-butane. Furthermore, reactors are not replaced only because of old age. They are subject to explosion, in which case the owner or operator would be given no opportunity to plan conversion of all production equipment so the replacement reactor could use another feedstock.

Also, reactors may be operated in parallel with all emissions routed to a single product recovery absorber. If a reactor required replacement because of explosion or other damage, n-butane or another nonbenzene feedstock would be required for the new reactor, while the other reactors could continue to use benzene. But the associated product recovery absorber and refining system may still be designed for benzene use only. Such a situation could present operational problems. The Administrator has already decided not to require existing sources to convert to a nonbenzene feedstock. Designating individual pieces of equipment as the source could have essentially the same consequences. Therefore, he decided against this option.

Next, the Administrator considered designating as the source a maleic anhydride production unit; i.e., a functionally integrated combination of reactor(s), recovery absorber(s), and refining systems. In this case, if an existing reactor exploded and had to be replaced, the new reactor could use benzene. However, as this group of equipment aged and had to be substantially or partially replaced, the new grouping of equipment would have to use a nonbenzene feedstock. Similarly, if the capacity of a maleic anhydride plant was increased by adding a new grouping of this functionally integrated equipment, that equipment would have to use a nonbenzene feedstock. Designating the source in this way appeared to be most consistent with the Administrator's decision not to require conversion of existing sources to a nonbenzene feedstock because of technological and economic uncertainties. However, when a firm is preparing for major construction; i.e., substantially replacing existing equipment or increasing capacity, it has the opportunity to incorporate into its planning the use of a nonbenzene feedstock. In these cases, the Administrator considers requiring the use of a nonbenzene feedstock reasonable.

Therefore, the grouping of facilities designated as the source to which the proposed standard applies is a maleic anhydride production unit. If construction of a maleic anhydride production unit were commenced after proposal of the standard, it would be considered new. If a new maleic anhydride production unit were added to an existing plant, it would be considered new. If an existing maleic anhydride production unit were completely replaced or if it were partially replaced and met the criterion for being "reconstructed," it would be considered new. Due to the way in which "modification" is defined in Section 61.02(j), if capacity or other physical changes were made to an existing maleic anhydride production unit, such as the addition of a reactor, and if there were no concomitant increase in benzene emissions (in mass per unit time) from the unit, the unit would not be considered "modified" and would still be considered an existing source. If emissions did increase, however, the unit would be considered modified and new.

Selection of the Format of the Standard

A number of different formats could be selected to limit benzene emissions from existing sources. These include concentration standards, mass standards limiting emissions in terms of benzene per unit of maleic anhydride produced, and mass standards limiting emissions in terms of benzene per unit of benzene supplied to the reactor.

Typically, a concentration standard is preferred over a mass standard because a mass standard requires more measurements and conversion calculations. Exhaust gas flow rates and raw material or product flow rates have to be measured, and concentration measurements have to be converted to mass measurements.

The standard for maleic anhydride plants is based on two types of control devices—incineration and carbon adsorption. In both cases, there is a potential for air dilution. Excess air is used in incinerators to ensure complete combustion, and the quantity of excess air used can vary. Carbon adsorption systems use air to cool the bed during the regeneration cycle. The cooling air strips residual benzene remaining on the regenerating bed and consequently must be controlled in the bed that is in the adsorption phase of the cycle. Again, the quantity of cooling air used can vary among adsorption units. Due to the potential for air dilution, correction factors are necessary to ensure that measurements of emissions from all control devices are referenced to the same basis, and that the quantity of benzene emitted is the same no matter how much excess air is used in an incinerator or how much cooling air is used in a carbon adsorption unit.

If incinerators are used, correction factors referencing all calculations to a specific oxygen concentration level in the exhaust gases are a solution to the problem of using varying quantities of excess air. These factors, however, do not compensate for indirect air dilution resulting from combustion of more fuel and air than is necessary. This situation occasionally arises where steam boilers are pressed into service as incinerators. Even though the exit gas concentrations are low in these cases, the volume is so large that emissions are occasionally higher than if an incinerator were used. In any event, a concentration standard would require a measurement of exhaust gas oxygen concentration.

If carbon adsorption were used, the cooling air flow low rate and the total flow rate would have to be measured, and the cooling air flow rate subtracted from the total flow rate. Measurement of the cooling air flow rate to a regenerating bed could be difficult.

Alternatively, an oxygen correction factor could be used that references calculations to the oxygen concentration level of the absorber waste gas stream as it is released from the absorber. In this case, two measurements of oxygen concentration level would be required: the absorber waste gas stream and the exhaust gases discharged to the atmosphere.

In comparison, concentration, total flow rate, and benzene feed rate or the maleic anhydride production rate would have to be measured to calculate mass emissions. Maleic anhydride plants already measure the benzene feed rate because most plants must operate below the benzene explosive limit. Therefore, enforcement of a mass standard would require no more measurements and calculations than a concentration standard.

Also, it is possible that some expansion of existing plants might take place by the addition of n-butane oxidation reactors to an expanded existing maleic anhydride refining system, which also continued to refine maleic anhydride from benzene oxidation reactors. In this situation, the waste gas stream from the product recovery absorber would be a mixture of n-butane and benzene oxidation waste gases. As a result, enforcement of a concentration standard, or a mass standard limiting benzene emissions in terms of maleic anhydride production, would effectively give a source combining n-butane and benzene oxidation a higher emission limit than a benzene oxidation source of the same capacity. A mass standard limiting emissions in terms of benzene per unit of benzene supplied to the reactor, however, would avoid this potential problem. Therefore, this format has been selected to limit emissions from existing sources, both to avoid this problem and because this format would minimize required measurements for enforcement.

A mass standard limiting emissions in terms of benzene per unit of benzene supplied to the reactor, however, is not

appropriate for new maleic anhydride production facilities. Since the basis for the standard for new sources assumes n-butane oxidation, new sources are expected to have no benzene emissions. However, the quantity of emissions considered to be "zero" depends on the measurement method. Consequently, the format to limit emissions from new sources is no detectable benzene emissions as measured with Test Method 110 specified in the proposed standard for benzene emissions from maleic anhydride plants.

Selection of Numerical Emission Limits

As discussed above, the format selected for the proposed standard as applied to existing sources was benzene emissions per unit of benzene fed to the reactor. Benzene emissions from a source are a function of the efficiency of the conversion of benzene to maleic anhydride and other organic byproducts in the reactor and the efficiency of the emission control device.

With regard to the reactor conversion efficiency, data available in published literature indicate that uncontrolled benzene emissions from the product recovery absorber and refining system represent 3 to 10 percent of the benzene fed to the reactor. This range in conversion efficiency is caused by variations in operating parameters, including the age of the catalyst. To include consideration of normal process fluctuation, a conversion efficiency of 90 percent was selected. Based on this conversion efficiency, the uncontrolled emission rate is 110 kilograms (22 pounds) of benzene emitted per 100 kilograms (220 pounds) of benzene fed to the reactors.

As discussed earlier, a control level of 97 percent has been selected as the basis for the proposed standard for existing sources. The numerical emission limit, therefore, is selected as 0.30 kilogram of benzene per 100 kg (0.30 lb/100 lb) of benzene fed to the reactor(s).

Selection of Emission Test Methods

The proposed emission test method for determining benzene emissions at sources using benzene as a feedstock is Method 110, which requires the use of a gas chromatograph with a flame ionization detector.

The averaging time selected for measuring benzene emissions by Test Method 110 at sources in maleic anhydride plants is based on the type of control device used. If a control device such as a carbon adsorber that operates in cycles is used, the averaging time for one run is equivalent to one cycle of the unit. Potential fluctuations in emissions may occur over the operating cycle of a carbon adsorber. Requiring that each run include an entire control device operating cycle ensures that these potential fluctuations in emissions are measured. A cycle in the monitoring of a carbon adsorption unit begins when air containing benzene is fed to the reactor and continues through the adsorption, desorption, and cooling and drying stages. For control devices such as incinerators, large fluctuations in emissions are not expected during normal operation, and the averaging time selected for each run was 1 hour. An emission test for benzene emissions is to consist of three contiguous runs as described above. The arithmetic mean of the results of three runs is to be used to determine compliance. Equivalent or alternative emission test methods may be used if they are approved by the Administrator.

Selection of Emission Monitoring Requirements

The objective of monitoring requirements is to provide a quick and easy means for enforcement personnel to ensure that an emission control system installed to comply with the standard is properly operated and maintained. For sources in maleic anhydride plants, the most straightforward means of ensuring proper operation and maintenance would be to monitor emissions released to the atmosphere. Preliminary indications are that a continuous emission monitoring system employing gas chromatography to measure benzene emissions would cost about $35,000. Since this cost is considered reasonable, the proposed standard includes monitoring requirements for plants using benzene as the feedstock.

Gas chromatography with a flame ionization detector, or an equivalent benzene monitoring system, is required. This system has to be operational prior to conducting the emission tests required under Section 61.93 so the continuous monitoring system can be evaluated.

The standard requires that the composition of reference gases used for the daily span check calibration of monitoring equipment be certified by the gas manufacturer. To certify composition, the concentrations of gases contained in each cylinder must have been determined by direct analysis with the analytical instrument being calibrated on the day of analysis. Calibration (Section 5.2.3.2 of Test Method 110) of the analytical procedure is performed using gases that have had their concentrations verified: (1) by comparison to gas mixture prepared in accordance with the procedure described in Section 7.1 of Test Method 110 and using 99 mole percent benzene, or (2) by direct analysis by the National Bureau of Standards.

The averaging time selected for determining the level of emissions with the continuous monitor is equivalent to the averaging time of an emission test; that is, three operating cycles for carbon adsorption systems, or 3 hours for other control systems.

Upon written application, the Administrator may approve alternative monitoring procedures or systems for specified conditions. For example, it is possible that a plant would be allowed to report benzene emissions in parts per million, instead of kilograms of benzene emitted per kilograms of benzene fed to the reactor, if it could demonstrate that it is meeting the standard using this method.

Public Hearing

A public hearing will be held to discuss the listing of benzene as a hazardous air pollutant under Section 112 and the proposed standard for maleic anhydride in accordance with Sections 112(b)(1)(B) and 307(d)(5) of the Clean Air Act. Person wishing to make oral presentations on the listing of benzene or the proposed standard for maleic anhydride plants should contact EPA at the address given in the *Addresses* section of this preamble. Oral presentations will be limited to 15 minutes each. Any member of the public may file a written statement before, during, or within 30 days after the hearing. Written statements should be addressed to the Central Docket Section address given in the *Addresses* section of this preamble and should refer to docket number OAQPS 79–3.

A verbatim transcript of the hearing and written statements will be available for public inspection and copying during normal working hours at EPA's Central Docket Section in Washington, D.C. (see *Addresses* section of this preamble).

Docket

The docket is an organized and complete file of all the information submitted to or otherwise considered by EPA in the development of this proposed rulemaking. The principal purposes of the docket are (1) to allow members of the public and industries involved to identify and locate documents so they can intelligently and effectively participate in the rulemaking process, and (2) to serve as the record in case of judicial review.

Miscellaneous

As prescribed by Section 112, the proposal of this standard was preceded by the Administrator's determination that benzene is a hazardous air pollutant as defined in Section 112(a)(1) of the Act. Benzene was added to the list of hazardous air pollutants on June 8, 1977. The Administrator, however, will consider information alleged to show that benzene does not cause or contribute to air pollution that may reasonably be anticipated to result in an increase in mortality or an increase in serious, irreversible, or incapacitating, reversible illness.

In accordance with Section 117 of the Act, publication of this proposal was preceded by consultation with appropriate advisory committees, independent experts, and Federal departments and agencies. The Administrator will welcome comments on all aspects of the proposed regulations, including health, economic, and technological issues, and on the proposed test method. Even though 97 percent control is the basis for the proposed standard, the Administrator has reserved the option of considering promulgation of a standard based on 99 percent control. For this reason, comments on the technological and economic aspects of requiring 99 percent control are specifically invited.

Recent information indicates that two benzene-based plants are considering conversion to an n-butane feedstock. In addition, one State has recently promulgated generic standards for toxic pollutants that may require more control of benzene than is currently assumed in the emission reduction estimates projected for this regulation. EPA will monitor these potential changes during the proposal period and evaluate their impact on emissions.

The Administrator welcomes comments on the appropriateness of the proposed regulation in light of these factors and invites suggestions and comments on alternatives to the NESHAP regulation to control benzene emissions from maleic anhydride plants. The Agency invites discussion of any alternative approaches that may achieve comparable health protection with less burden to EPA and to industry than Section 112 regulation. Specifically, the Agency requests comment on the feasibility and desirability of voluntarily developed compliance agreements, negotiated between a source and EPA or the State, as a means of assuring adequate control of these facilities.

Under EPA's sunset policy for reporting requirements in regulations, the reporting requirements in this regulation will automatically expire 5 years from the date of promulgation unless affirmative action is taken to extend them. To accomplish this, a provision automatically terminating the reporting requirements at that time will be included in the text of the final regulations.

This regulation will be reviewed 5 years from the date of promulgation. This review will include an assessment of such factors as new information on health effects, the need for integration with other programs, the existence of alternative methods, enforceability, and improvements in emission control technology.

Dated: April 4, 1980.

Douglas M. Costle,

Administrator.

It is proposed that Part 61 of Chapter I, Title 40 of the *Code of Federal Regulations* be amended by adding a new Subpart H, a new Test Method 110 to Appendix B, and a new Appendix C containing Supplements A and B to Method 110, as follows:

Subpart H—National Emission Standard for Benzene Emissions from Maleic Anhydride Plants

Sec.
61.90 Applicability and designation of source.
61.91 Definitions.
61.92 Emission standard and compliance provisions.
61.93 Excess emissions.
61.94 Emission test and procedures.
61.95 Emission monitoring.
61.96 Recordkeeping requirements.

Authority: Sec. 112, 114, and 301(a), Clean Air Act as amended [42 U.S.C. 7412, 7414, and 7601(a)], and additional authority as noted below.

Subpart H—National Emission Standard for Benzene Emissions from Maleic Anhydride Plants

§ 61.90 Applicability and designation of source.

(a) The provisions of this subpart are applicable to the following source: any maleic anhydride production unit that produces a total of 500 Mg or more per year of maleic anhydride, maleic acid, or both, either as an end product or as an intermediate product.

§ 61.91 Definitions.

Terms used in this subpart are defined in the Act, in Subpart A of this part, or in this section as follows:

(a) "Continuous monitoring system" means the total equipment used to sample, to analyze, and to provide a permanent record of emissions or process parameters.

(b) "Control system malfunction" means any sudden and unavoidable failure of air pollution control equipment. A failure caused entirely or in part by deficiencies in design, poor maintenance, careless operation, or other preventable upset condition or preventable equipment breakdown is not considered a malfunction.

(c) "Controlled shutdown" means the termination of benzene feed to the reactor(s) in a manner that results in the least amount of benzene emissions without damage to air pollution control or process equipment.

(d) "Maleic anhydride production unit" means any functionally integrated combination of reactors, product recovery absorbers, and refining systems used to produce maleic anhydride or maleic acid.

(e) "Product recovery absorber" means any equipment in which a gas stream containing maleic anhydride or maleic acid is contacted with an absorbent liquid to recover the maleic anhydride, maleic acid, or both as a mixture.

(f) "Reactor" means any vessel in which benzene or an other feedstock is partially or totally oxidized to maleic anhydride or maleic acid.

(g) "Refining system" means equipment used to separate maleic anhydride or maleic acid from other material or liquid and to dehydrate maleic acid to maleic anhydride. It also includes pieces of equipment used to keep refining columns, evaporators, crystallizers, and other unit separation process equipment under negative pressure.

(h) "Run" means the net period of time during which an emission sample is collected.

(i) "Reconstruction" means the replacement of components of an existing source to such an extent that:

(1) The fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable, entirely new source; and

(2) It is feasible, considering economic impacts and the technological problems associated with retrofit, to meet the applicable standard for new sources set forth in this subpart.

(j) "Fixed capital cost" means the capital needed to provide all the depreciable components.

§ 61.92 Emission standard and compliance provisions.

(a) No owner or operator of a source to which this subpart applies shall cause benzene to be emitted into the atmosphere from the source in excess of

the appropriate emission limit as stated below:

(1) Existing source—0.30 kg/100 kg of benzene fed to the reactor(s), averaged over three cycles for carbon adsorbers or over 3 hours for other control systems. This emission limit does not apply during a control system malfunction if the Administrator has approved a controlled shutdown mass emission limit under § 61.93.

(2) New source—no detectable benzene emissions as measured with Test Method 110.

(b) For the duration of a control system malfunction, no owner or operator of a source to which this subpart applies shall cause the total mass of benzene to be emitted from the source in excess of the controlled shutdown mass emission limit, established under § 61.93(a), applicable to the source.

(c) The owner or operator of each source shall maintain and operate the source including associated air pollution control equipment in a manner consistent with good air pollution control practice for minimizing benzene emissions. Determination of whether acceptable operating and maintenance procedures are being used will be based on information available to the Administrator, which may include but is not limited to monitoring results, review of operating and maintenance procedures, and inspection of the source.

(d) Upon reconstruction, an existing source shall become a new source for purposes of this subpart.

§ 61.93 Excess emissions.

(a) Controlled shutdown mass emission limit. (1) The owner or operator of each source subject to the emission limitations in § 61.92(a)(1) and who uses benzene as a feedstock shall include in the initial source report required under § 61.10, a calculation of the total uncontrolled mass benzene emissions that would occur from each source for which an emission limitation is prescribed under § 61.92(a)(1) during a controlled shutdown. The following information is also to be included:

(i) A complete step-by-step description of the controlled shutdown procedure for each process for which an emission limitation is prescribed under § 61.92(a)(1), including an account that details each step in the procedure.

(ii) The length of time it takes for each step of the controlled shutdown, from initiation to completion.

(iii) The amount of benzene emissions computed to occur in the absence of air pollution control equipment during each step of the controlled shutdown based on production rates for the process running at full capacity.

(2) The Administrator shall, within 60 days of receipt of the information specified in paragrph (a)(1) of this section, notify the plant owner or operator whether he approves or disapproves, as the numerical emission limit applicable during a control system malfunction, the benzene emissions computed to occur during a controlled shutdown in accordance with paragraph (a)(1) of this section. In making this determination, the Administrator shall consider the information submitted under paragraph (a)(1) of this section. The Administrator may also consider any other information available to him or that he may reasonably require, in addition to sound engineering practices.

(b) *Excess emissions reporting.* (1) For each occurrence of benzene emissions in excess of the numerical emission limit, specified in § 61.92(a)(1), the owner or operator of that plant shall report the occurrence to the Administrator within 10 days after the occurrence. Emissions in excess of the numerical emission limit are those indicated by measurements by an emission test or by a continuous monitoring system over the following period of time.

(i) When a control device is used that operates in cycles, such as a carbon adsorber, all periods equivalent to three contiguous cycles of the control device during which the average emissions exceed the appropriate numerical emissions limit in § 61.92(a)(1). The emissions measured for any one cycle are to be used in calculating an average only once; running averages are not required.

(ii) When any other control device is used, all 3-hour periods during which the average emissions exceed the appropriate numerical emission limit in § 61.92(a)(1). The emissions measured for any one cycle are to be used in calculating an average only once; running averages are not required.

(2) The owner or operator shall submit the following information as a minimum in the report required by paragraph (b)(1) of this section:

(i) The identity of the stack and other emission points where the excess emissions occurred.

(ii) The identity of the equipment causing the excess emissions.

(iii) The owner or operator shall also state whether or not he believes a control system malfunction has occurred.

(3) If the owner or operator states that a control system malfunction has occurred, the following information as a minimum is also to be included in the report required under paragraph (b)(1) of this section:

(i) The total mass of benzene emissions that occurred during the control system malfunction.

(ii) The nature and cause of the excess emissions.

(iii) The steps taken to remedy the malfunction and the steps taken or planned to prevent the recurrence of such malfunctions.

(iv) Documentation that the air pollution control equipment, process equipment, or processes were at all times maintained and operated, to the maximum extent practicable, in a manner consistent with good practice for minimizing emissions, and were designed in accordance with good engineering practices.

(v) Continuous monitoring data, operating data, and calculations used in determining the magnitude of excess emissions, including but not limited to—

(A) The time and duration of the control system malfunction;

(B) The benzene feed rate to the reactors at the beginning of and during the control system malfunction;

(C) The benzene conversion rate in the reactor at the beginning of and during the control system malfunction;

(D) The production rate at the beginning of and during the control system malfunction; and

(E) The uncontrolled benzene emission rate during the control system malfunction in kilograms per 100 kilograms of benzene to the reactor.

(4) The Administrator shall determine whether a contol system malfunction has occurred based on the data submitted under paragraphs (b) (2) and (3) of this section. In making this determination, the Administrator may also consider any other information available to him or that he may reasonably require, in addition to sound engineering practices. If the Administrator determines that a control system malfunction has occurred, he shall determine whether the emissions in excess of the emission limits established in accordance with paragraph (a) of this section have been exceeded. The Administrator shall notify the owner or operator of this determination in case of violation within 60 days after receipt of the report required under paragraph (b) of this section.

§ 61.94 Emission test and procedures.

(a) Unless a waiver of emission testing is obtained under § 61.13, the owner or operator subject to the provisions of this subpart shall test emissions from all existing sources in

which benzene is used as a feedstock within 90 days of the effective date.

(b) The owner or operator of each source shall provide the Administrator 30 days prior notice of the emissions test to afford the Administrator the opportunity to have an observer present.

(c) Any emission test is to be conducted while the equipment being tested is operating at the maximum production rate at which the equipment will be operated.

(d) Where possible, each sample is to be analyzed within 24 hours, but in no case later than 72 hours of sample collection. Emissions are to be determined within 30 days after the emisson test. The owner or operator shall report the determinations to the Administrator by a registered letter dispatched before the close of the next business day following the determination.

(e) The owner or operator shall retain at the plant and make available, upon request, for inspection by the Administrator, for a minimum of 2 years, records of emission test results and other data needed to determine emissions.

(f) The owner or operator shall use the following test methods to determine benzene emissions from any source for which an emissions limit is prescribed in § 61.92, unlesss an alternative or equivalent method has been approved by the Administrator. If the Administrator finds reasonable grounds to dispute the results obtained by an equivalent or alternative method, he may require the use of a reference method. If the results of the reference and equivalent or alternative methods do not agree, the results obtained by the reference method prevail, and Administrator may notify the owner or operator that approval of the method previously considered to be equivalent or alternative is withdrawn.

(1) Test Method 1 of Appendix A to Part 60 is to be used to determine sample and velocity traverses.

(2) Test Method 2 of Appendix A to Part 60 is to be used to determine velocity and volumetric flow rate.

(3) Test Method 110 of Appendix B to this part is to be used to determine benzene emissions from any source for which an emission limit is prescribed in § 61.92.

(g) Each emission test is to consist of three runs. One sample containing a minimum volume of 50 liters corrected to standard conditions, is to be collected for each run. For the purpose of determining emissions, the average of the results from all three runs is to apply. The average is to be computed on a time-weighted basis.

(h) Where a control device is used that operates in cycles, the sampling time for each run is the time period of one complete cycle. Where any other control device is used, sampling time is to be taken over a minimum of 1 hour.

(i) The sampling site is to be at least two stack or duct diameters downstream and one-half diameter upstream from any flow disturbance such as a bend, expansion, contraction, or visible flame. The sampling point in the duct is to be at the centroid of the cross section. The sample is to be extracted at a rate proportional to the gas velocity at the sampling point. For a rectangular cross section an equivalent diameter is to be determined from the following equation:

$$\text{equivalent diameter} = \frac{2\,(\text{length})(\text{width})}{\text{length} + \text{width}}$$

(j) The reactor feed rate is to be determined during each testing period by a method approved by the Administrator.

(k) The mass emissions in kilograms of benzene per 100 kilograms of benzene fed to the reactor are to be computed by using the following equation:

$$E_B = \frac{[C_B\ (3.24)\ Q \times 10^{-6}][100]}{P_{BM}}$$

where

E_B is kg of benzene/100 kg of benzene fed to the reactor.

C_B is the concentration of benzene as measured by Test Method 110 (ppmv).

3.24 is the vapor density of benzene at 1 atm and 20° C in kg/m³.

Q is the volumetric flow rate in m³/hr as determined by Reference Method 2 of Appendix A to Part 60 of this chapter.

10^{-6} is the conversion factor for ppm.

P_{BM} is the benzene feed rate to the reactor in kg/hr.

(Sec. 114, Clean Air Act as amended [42 U.S.C. 7414])

§ 61.95 Emission monitoring.

(a) The owner or operator of each source to which this subpart applies shall install and use a continuous monitoring system to monitor the concentrations of benzene emissions discharged to the atmosphere from all existing sources that use benzene as a feedstock. The owner or operator shall also monitor the quantity of benzene fed per hour to each reactor and the exhaust gas flow rate from any device that may discharge benzene emissions into the atmosphere. He shall use the data required to be collected by this paragraph to calculate total mass emissions of benzene in kilograms per 100 kg of benzene fed to the reactor in accordance with the equation in § 61.94(k).

(b) The continuous monitoring system to be installed in accordance with paragraph (a) of this section is to be a device that obtains air samples from one or more emission points on a continuous, sequential basis and analyzes the samples by gas chromatography using a flame ionizaton detector.

(c) When the effluents from a single source or two or more sources subject to the same emission standards are combined before being released to the atmosphere, the owner or operator may install applicable continuous monitoring systems on each effluent or on the combined effluent. When the sources are not subject to the same emission standards, separate continuous monitoring systems shall be installed on each effluent. When the effluent from one source is released to the atmosphere through more than one point, the owner or operator shall install applicable continuous monitoring systems on each separate effluent unless the installation of fewer systems is approved by the Administrator.

(d) All continuous monitoring systems are to be installed so that representative measurements of emissions are obtained and are to be operational prior to conducting emission tests under § 61.94. Verification of operational status is to consist of, at the minimum, completion of the manufacturer's written requirements or recommendations for checking the operation or calibration of the device.

(e) During any emission tests required under § 61.94 and at such other times as may be required by the Administrator under Section 114 of the Act, the owner or operator of each source shall furnish the Administrator a written report of the measurements of benzene made by the continuous monitoring system during the emission test within 60 days.

(f) All continuous monitoring systems used in accordance with this section are to complete a minimum of one cycle of operation (sampling, analyzing, and data recording) for each successive 15-minute period.

(g) Owners or operators of all continuous monitoring systems installed in accordance with this subpart shall check the zero and span drift at least once daily in accordance with the method prescribed by the manufacturer of such systems unless the manufacturer of such systems recommends adjustments at shorter intervals, in which case such recommendations shall be followed. The daily span check is to be conducted with reference gas containing a concentration of benzene determined to be equivalent to the emission limit for that source based on the emission tests required by § 61.94.

(h) The calibration is to be done with either—

(1) A calibration mixture prepared from the liquids and gases specified in Section 5.2.1 and 5.2.2 of Test Method 110 and in accordance with Section 7.1 of Test Method 110; or

(2) A calibration gas cylinder standard containing the appropriate concentration of benzene. The gas composition of the calibration gas cylinder standard is to have been certified by the manufacturer. The manufacturer must have recommended a maximum shelf life for each cylinder so gas standards will not be used if their concentration has changed greater than ±5 percent from the certified value. The data of gas cylinder preparation, certified benzene concentration, and recommended maximum shelf life must have been affixed to the cylinder before shipment from the manufacturer to the buyer. If a gas chromatograph is used as the continuous monitoring system, these gas mixtures may be used directly to prepare a chromatograph calibration curve as described in Section 7.2 of Test Method 110 for certification of cylinder standards and for establishment and verification of calibration standards.

(i) After receipt and consideration of written application, the Administrator may approve use of an alternative or equivalent continuous monitoring system, alternative monitoring procedures, or alternative monitoring requirements.

(Sec. 114, Clean Air Act as amended [42 U.S.C. 7414])

§ 61.96 Recordkeeping requirements.

(a) The owner or operator of each source to which this subpart applies shall maintain daily records of the monitoring information specified in § 61.95(a).

(b) Records are to be retained at the source and made available for inspection by the Administrator for a minimum of 2 years.

(Sec. 114, Clean Air Act as amended [42 U.S.C. 7414])

Appendix B—Test Methods

Method 110. Determination of Benzene From Stationary Sources

Performance of this method should not be attempted by persons unfamiliar with the operation of a gas chromatograph, nor by those who are unfamilar with source sampling, because knowledge beyond the scope of this presentation is required. Care must be exercised to prevent exposure of sampling personnel to benzene, a carcinogen.

1. Applicability and Prinicple

1.1 Applicability. This method applies to the measurement of benzene in stack gases from processes as specified in the regulations. The method does not remove benzene contained in particulate matter.

1.2 Principle. An integrated bag sample of stack gas containing benzene and other organics is subjected to gas chromatographic (GC) analysis, using a flame ionization detector (FID).

2. Range and Sensitivity

The range of this method is 0.1 to 70 ppm. The upper limit may be extended by extending the calibration range or by diluting the sample.

3. Interferences

The chromatograph columns and the corresponding operating parameters herein described normally provide an adequate resolution of benzene; however, resolution interferences may be encountered on some sources. Therefore, the chromatograph operator shall select the column and operating parameters best suited to his particular analysis problem, subject to the approval of the Administrator. Approval is automatic provided that the tester produces confirming data through an adequate supplemental analytical technique, such as analysis with a different column or GC/mass spectroscopy, and has the data available for review by the Administrator.

4. Apparatus

4.1 Sampling (see Figure 110–1). The sampling train consists of the following components:

4.1.1 Probe. Stainless steel, Pyrex * glass, or Teflon tubing (as stack temperature permits), equipped with a glass wool plug to remove particulate matter.

4.1.2 Sample Lines. Teflon, 6.4 mm outside diameter, of sufficient length to connect probe to bag. Use a new unused piece for each series of bag samples that constitutes an emission test and discard upon completion of the test.

4.1.3 Quick Connects. Stainless steel, male (2) and female (2), with ball checks (one pair without) located as shown in figure 110–1.

4.1.4 Tedlar or aluminized Mylar bags, 100 L capacity, to contain sample.

4.1.5 Bag Containers. Rigid leakproof containers for sample bags with covering to protect contents from sunlight.

4.1.6 Needle Valve. To adjust sample flow rate.

4.1.7 Pump. Leak-free with minimum of 2 L/min capacity.

4.1.8 Charcoal Tube. To prevent admission of benzene and other organics to the atmosphere in the vicinity of samplers.

4.1.9 Flow Meter. For observing sample flow rate; capable of measuring a flow range from 0.10 to L/min.

4.1.10 Connecting Tubing. Teflon, 6.4 mm outside diameter, to assemble sampling train (Figure 110–1.)

4.2 Sample Recovery. Teflon tubing, 6.4 mm outside diameter, is required to connect chromatograph sample loop for sample recovery. Use a new unused piece for each series of bag samples that constitutes an emission test and discard upon conclusion of analysis of those bags.

4.3 Analysis. The following equipment is needed:

4.3.1 Gas Chromatograph. With FID, potentiometric strip chart recorder and 1.0 to 2.0 mL sampling loop in automatic sample valve. The chromatographic system shall be capable of producing a response to 0.1ppm benzene that is at least as great as the average noise level. (Response is measured from the average value of the base line to the maximum of the waveform, while standard operating conditions are in use.)

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* Mention of trade names or specific products does not constitute endorsement by the U.S. Environmental Protection Agency.

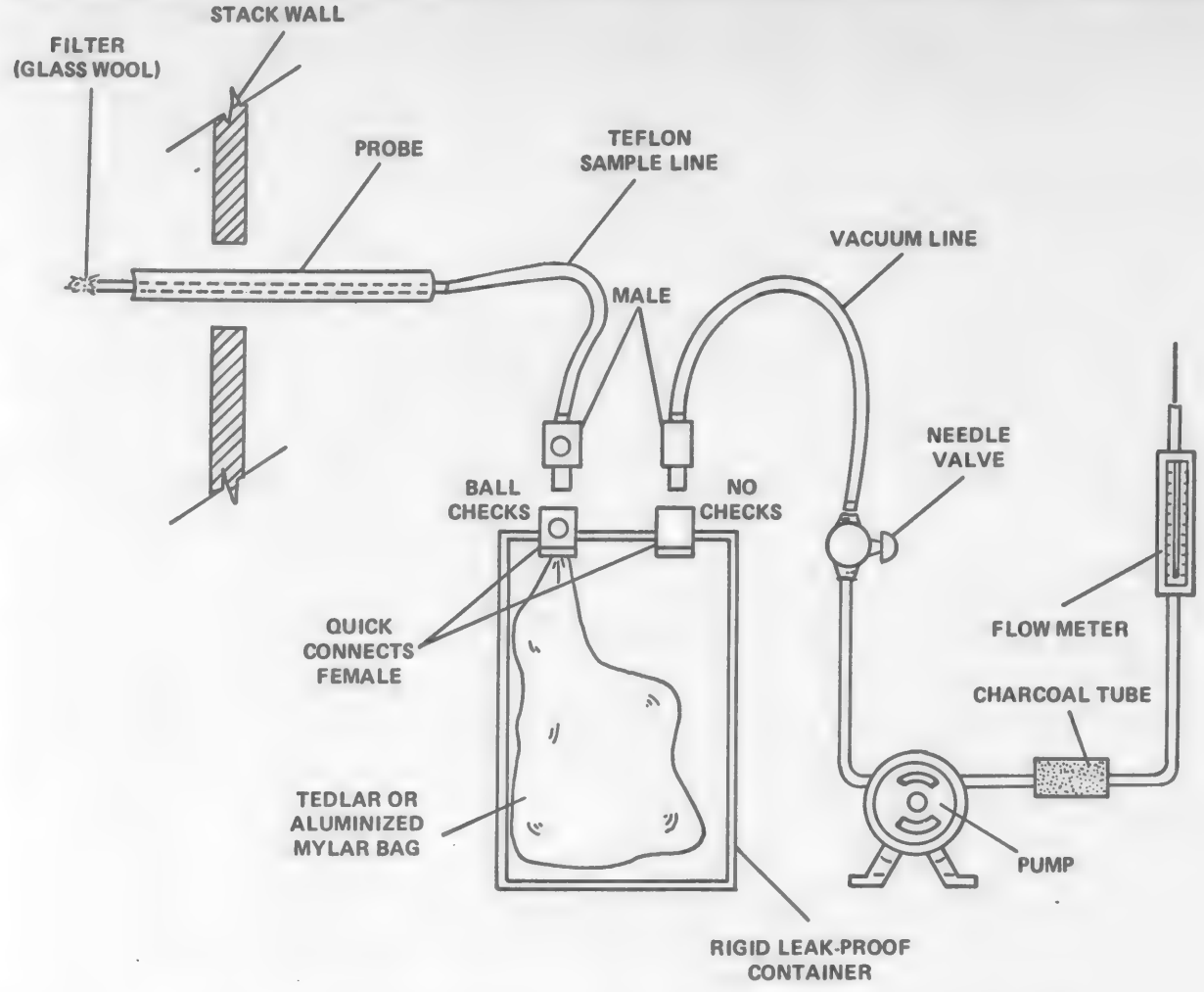

Figure 110-1. Integrated-bag sampling train. (Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.)

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4.3.2 Chromatographic Columns. Columns as listed below. The analyst may use other columns provided that the precision and accuracy of the analysis of benzene standards are not impaired and he has available for review information confirming that there is adequate resolution of the benzene peak. (Adequate resolution is defined as an area overlap of not more than 10 percent of the benzene peak by an interferent peak. Calculation of area overlap is explained in Appendix E, Supplement A: "Determination of Adequate Chromatographic Peak Resolution.")

4.3.2.1 Column A: Benzene in the Presence of Aliphatics. Stainless steel, 2.44 m by 3.2 mm, containing 10 percent 1,2,3-tris (2-cyanoethoxy) propane (TCEP) on 80/100 Chromosorb P AW.

4.3.2.2 Column B: Benzene With Separation of the Isomers of Xylene. Stainless steel, 1.83 m by 3.2 mm, containing 5 percent SP 1,200/1.75 percent Bentone 34 on 100/120 Suplecoport.

4.3.3 Flow Meters (2). Rotameter type, 100 mL/min capacity.

4.3.4 Gas Regulators. For required gas cylinders.

4.3.5 Thermometer. Accurate to 1° C, to measure temperature of heated sample loop at time of sample injection.

4.3.6 Barometer. Accurate to 5 mmHg, to measure atmospheric pressure around gas chromatograph during sample analysis.

4.3.7 Pump. Leak-free, with minimum of 100 mL/min capacity.

4.3.8 Recorder. Strip chart type, optionally equipped with either disc or electronic integrator.

4.3.9 Planimeter. Optional, in place of disc or electronic integrator, on recorder, to measure chromatograph peak areas.

4.4 Calibration. Sections 4.4.2 through 4.4.5 are for the optional procedure in Section 7.1.

4.4.1 Tubing. Teflon, 6.4 mm outside diameter, separate pieces marked for each calibration consentration.

4.4.2 Tedlar or Aluminized Mylar Bags. 50 L capacity, with valve; separate bag marked for each calibration concentration.

4.4.3 Syringes. 1.0 μL and 10 μL, gas tight, individually calibrated to dispense liquid benzene.

4.4.4 Dry Gas Meter, With Temperature and Pressure Gauges. Accurate to ±2 percent, to meter nitrogen in preparation of standard gas mixtures, calibrated at the flow rate used to prepare standards.

4.4.5 Midget Impinger/Hot Plate Assembly. To vaporize benzene.

5. Reagents

Use only reagents that are of chromatographic grade.

5.1 Analysis. The following are needed for analysis:

5.1.1 Helium or Nitrogen. Zero grade, for chromatograph carrier gas.

5.1.2 Hydrogen. Zero grade.

5.1.3 Oxygen or Air. Zero grade, as required by the detector.

5.2 Calibration. Use one of the following options: either 1.2.1 and 5.2.2, or 5.2.3.

5.2.1 Benzene, 99 Mol Percent Pure. Certified by the manufacturer to contain a minimum of 99 Mol percent benzene; for use in the preparation of standard gas mixtures as described in Section 7.1.

5.2.2 Nitrogen. Zero grade, for preparation of standard gas mixtures as described in Section 7.1.

5.2.3 Cylinder Standards (3). Gas mixture standards (50, 10, and 5 ppm benzene in nitrogen cylinders). The tester may use cylinder standards to directly prepare a chromatograph calibration curve as described in Section 7.2.2, if the following conditions are met: (a) The manufacturer certifies the gas composition with an accuracy of ±3 percent or better (see Section 5.2.3.1). (b) The manufacturer recommends a maximum shelf life over which the gas concentration does not change by greater than ±5 percent from the certified value. (c) The manufacturer affixes the date of gas cylinder preparation, certified benzene concentration, and recommended maximum shelf life to the cylinder before shipment to the buyer.

5.2.3.1 Cylinder Standards Certification. The manufacturer shall certify the concentration of benzene in nitrogen in each cylinder by (a) directly analyzing each cylinder and (b) calibrating his analytical procedure on the day of cylinder analysis. To calibrate his analytical procedure, the manufacturer shall use, as a minimum, a three-point calibration curve. It is recommended that the manufacturer maintain (1) a high-concentration calibration standard (between 50 and 100 ppm) to prepare his calibration curve by an appropriate dilution technique; and (2) a low-concentration calibration standard (between 5 and 10 ppm) to verify the dilution technique used. If the difference between the apparent concentration read from the calibration curve and the true concentration assigned to the low-concentration standard exceeds 5 percent of the true concentration, the manufacturer shall determine the source of error and correct it, then repeat the three-point calibration.

5.2.3.2 Verification of Manufacturer's Calibration Standards. Before using, the manufacturer shall verify each calibration standard by (a) comparing it to gas mixtures prepared (with 99 Mol percent benzene) in accordance with the procedure described in Section 7.1 or by (b) having it analyzed by the National Bureau of Standards. The agreement between the initially determined concentration value and the verification concentration value must be within ±5 percent. The manufacturer must reverify all calibration standards on a time interval consistent with the shelf life of the cylinder standards sold.

5.2.4 Audit Cylinder Standards (2). Gas mixture standards with concentrations known only to the person supervising the analysis of samples. The audit cylinder standards shall be identically prepared as those in Section 5.2.3 (benzene in nitrogen cylinders). The concentrations of the audit cylinder should be: one low-concentration cylinder in the range of 5 to 20 ppm benzene and one high-concentration cylinder in the range of 100 to 300 ppm benzene. When available, the tester may obtain audit cylinders by contacting: U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Quality Assurance Branch (MD –77), research Triangle Park, North Carolina 27711. If audit cylinders are not available at the Environmental Protection Agency, the tester must secure an alternative source.

6. Procedure

6.1 Sampling. Assemble the sample train as shown in Figure 110–1. Perform a bag leak check according to Section 7.3.2. Join the quick connects as illustrated, and determine that all connections between the bag and the probe are tight. Place the end of the probe at the centroid of the stack, and start the pump with the needle valve adjusted to yield a flow that will more than half fill the bag in the specified sample period. After allowing sufficient time to purge the line several times, connect the vacuum line to the bag and evacuate the bag until the rotameter indicates no flow. At all times, direct the gas exiting the rotameter away from sampling personnel. At the end of the sample period, shut off the pump, disconnect the sample line from the bag, and disconnect the vacuum line from the bag container. Protect the bag container from sunlight.

6.2 Sample Storage. Keep the sample bags out of direct sunlight. Perform the analysis within 4 days of sample collection.

6.3 Sample Recovery. With a new piece of Teflon tubing identified for that bag, connect a bag inlet valve to the gas chromatograph sample valve. Switch the valve to receive gas from the bag through the sample loop. Arrange the equipment so the sample gas passes from the sample valve to a 100-mL/min rotameter with flow control valve followed by a charcoal tube and a 1-in. pressure gauge. The tester may maintain the sample flow either by a vacuum pump or container pressurization if the collection bag remains in the rigid container. After sample loop purging is ceased, always allow the pressure gauge to return to zero before activating the gas sampling valve.

6.4 Analysis. Set the column temperature to 80° C (176° F) for column A or 75° C (167° F) for column B, and the detector temperature to 225° C (437° F). When optimum hydrogen and oxygen flow rates have been determined, verify and maintain these flow rates during all chromatograph operations. Using zero helium or nitrogen as the carrier gas, establish a flow rate in the range consistent with the manufacturer's requirements for satisfactory detector operation. A flow rate of approximately 20 mL/min should produce adequate separations. Observe the base line periodically and determine that the noise level has stabilized and that base-line drift has ceased. Purge the sample loop for 30 sec at the rate of 100 mL/min, then activate the sample valve. Record the injection time (the position of the pen on the chart at the time of sample injection), the sample number, the sample loop temperature, the column temperature, carrier gas flow rate, chart speed, and the attenuator setting. From the chart, note the peak having the retention time corresponding to benzene, as determined in Section 7.2.1. Measure the benzene peak area, A_m, by use of a disc integrator, electronic integrator, or a planimeter. Record A_m and

the retention time. Repeat the injection at least two times or until two consecutive values for the total area of the benzene peak do not vary more than 5 percent. Use the average value of these two total areas to compute the bag concentration.

6.5 Determination of Bag Water Vapor Content. Measure the ambient temperature and barometric pressure near the bag. From a water saturation vapor pressure table, determine and record the water vapor content of the bag as a decimal figure. (Assume the relative humidity to be 100 percent unless a lesser value is known.)

7. Preparation of Standard Gas Mixtures, Calibration, and Quality Assurance

7.1 Preparation of Benzene Standard Gas Mixtures. (Optional procedure—delete if cylinder standards are used.) Assemble the apparatus shown in Figure 110–2. Evacuate a 50–L Tedlar or aluminized Mylar bag that has passed a leak check (described in Section 7.3.2) and meter in about 50 L of nitrogen. Measure the barometric pressure, the relative pressure at the dry gas meter, and the temperature at the dry gas meter. While the bag is filling, use the 10μL syringe to inject 10μL of 99+ percent benzene through the septum on top of the impinger. This gives a concentration of approximately 50 ppm of benzene. In a like manner, use the other syringe to prepare dilutions having approximately 10 ppm and 5 ppm benzene concentrations. To calculate the specific concentrations, refer to Section 8.1. These gas mixture standards may be used for 7 days from the date of preparation, after which time preparation of new gas mixtures is required. (Caution: If the new gas mixture standard is a lower concentration than the previous gas mixture standard, contamination may be a problem when a bag is reused.)

7.2 Calibration.

7.2.1 Determination of Benzene Retention Time. (This section can be performed simultaneously with Section 7.2.2.) Establish chromatograph conditions identical with those in Section 6.4, above. Determine proper attenuator position. Flush the sampling loop with zero helium or nitrogen and activate the sample valve. Record the injection time, the sample loop temperature, the column temperature, the carrier gas flow rate, the chart speed, and the attenuator setting. Record peaks and detector responses that occur in the absence of benzene. Maintain conditions, with the equipment plumbing arranged identically to Section 6.3, and flush the sample loop for 30 sec at the rate of 100 mL/min with one of the benzene calibration mixtures. Then activate the sample valve. Record the injection time. Select the peak that corresponds to benzene. Measure the distance on the chart from the injection time to the time at which the peak maximum occurs. This distance divided by the chart speed is defined as the benzene peak retention time. Since it is quite likely that there will be other organics present in the sample, it is very important that positive identification of the benzene peak be made.

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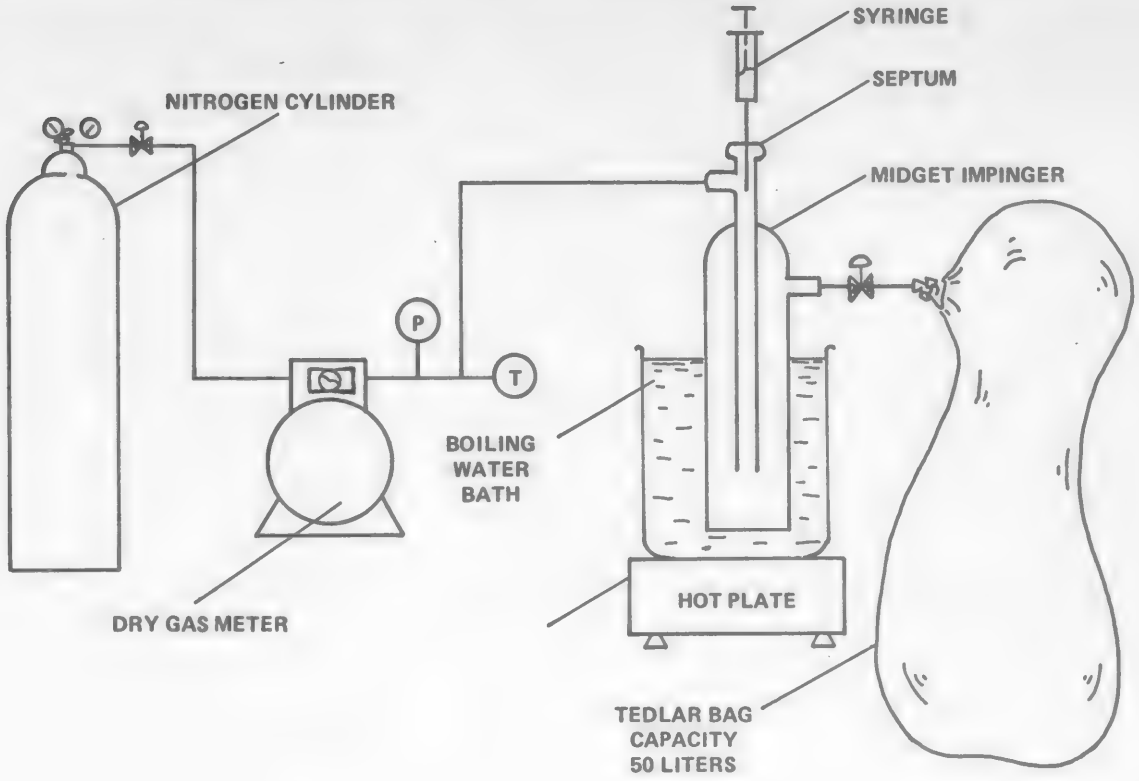

Figure 110-2. Preparation of benzene standards (optional).

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Question.

7.2.2 Preparation of Chromatograph Calibration Curve. Make a gas chromatographic measurement of each standard gas mixture (described in Section 5.2.3 or 7.1.1) using conditions identical with those listed in Sections 6.3 and 6.4. Flush the sampling loop for 30 sec at the rate of mL/min with one of the standard gas mixtures and activate the sampe valve. Record C_c, the concentration of benzene injected, the attenuator setting, chart speed, peak area, sample loop temperature, column temperature, carrier gas flow rate, and retention time. Record the laboratory pressure. Calculate A_c, the peak area multiplied by the attenuator setting. Repeat until two consecutive injection areas are within 5 percent, then plot the average of those two values versus C_c. When the other standard gas mixtures have been similarly analyzed and plotted, draw a straight line through the points derived by the least squares method. Perform calibration daily, or before and after each set of bag samples, whichever is more frequent.

7.3 Quality Assurance.

7.3.1 Analysis Audit. Immediately after the preparation of the calibration curve and before the sample analyses, perform the analysis audit described in Appendix E, Supplement B: "Procedure for Field Auditing GC Analysis."

7.3.2 Bag Leak Checks. While performance of this section is required after bag use, it is also advised that it be performed before bag use. After each use, make sure a bag did not develop leaks by connecting a water manometer and pressurizing the bag to 5 to 10 cm H_2O (2 to 4 in. H_2O). Allow to stand for 10 min. Any displacement in the water manometer indicates a leak. Also, check the rigid container for leaks in this manner. (Note: an alternative leak check method is to pressurize the bag to 5 to 10 cm H_2O or 2 to 4 in. H_2O and allow to stand overnight. A deflated bag indicates a leak.) For each sample bag in its rigid container, place a rotameter in line between the bag and the pump inlet. Evacuate the bag. Failure of the rotameter to register zero flow when the bag appears to be empty indicates a leak.

8. Calculations

8.1 Optional Benzene Standards Concentrations. Calculate each benzene standard concentration (C_c in ppm) prepared in accordance with Section 7.1 as follows:

$$C_c = \frac{B(0.2706)(10^3)}{V_m Y \frac{293}{T_m}\frac{P_m}{760}}$$

$$C_c = 701.9\,\frac{BT_m}{V_m Y P_m} \qquad (110\text{-}1)$$

where:

B = Volume of benzene injected, microliters.
V_m = Gas volume measured by dry gas meter, liters.
Y = Dry gas meter calibration factor, dimensionless.
P_m = Absolute pressure of the dry gas meter, mmHg.
T_m = Absolute temperature of the dry gas meter, °K.
0.2706 = Ideal gas volume of benzene at 293° K and 760 mmHg L/mL.
10^3 = Conversion factor [(ppm)(mL)/μL].

8.2 Benzene Sample Concentrations. From the calibration curve described in Section 7.2.2 above, select the value of C_c that corresponds to A_c. Calculate the concentration of benzene in the sample (C_s in ppm) as follows:

$$C_s = \frac{C_c P_r T_i}{P_i T_r (1-S_{wb})}, \qquad (110\text{-}2)$$

where:

C_s = Concentration of benzene in the sample, ppm.
C_c = Concentration of benzene indicated by the gas chromatograph, ppm.
P_r = Reference pressure, the barometric pressure recorded during calibration, mmHg.
T_i = Sample loop temperature at the time of analysis, °K.
P_i = Barometric pressure at time of analysis, mmHg.
Tr = Reference temperature, the sample loop temperature recorded during calibration, °K.
S_{wb} = Water vapor content of the bag sample, volume fraction.

9. References

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Appendix C

Supplement A—Determination of Adequate Chromatographic Peak Resolution

In this method of dealing with resoultion, the extent to which one chromatographic peak overlaps another is determined.

For convenience, consider the range of the elution curve of each compound as running from -2σ to $+2\sigma$. This range is used in other resolution criteria, and it contains 95.45 percent of the area of a normal curve. If two peaks are separated by a known distance, b, one can determine the fraction of the area of one curve that lies within the range of the other. The extent to which the elution curve of a contaminant compound overlaps the curve of a compound that is under analysis is found by integrating the contaminant curve over limits $b-2\sigma_s$ to $b+2\sigma_s$, where σ_s is the standard deviation of the sample curve.

There are several ways this calculation can be simplified. Overlap can be determined for curves of unit area; then actual areas can be introduced. The desired integration can be resolved into two integrals of the normal distribution function for which there are convenient calcualtion programs and tables. An example would be Program 15 in Texas Instruments Program Manual ST1, 1975, Texas Instruments, Inc., Dallas, Texas 75222.

$$\frac{1}{\sqrt{2\pi}\,\sigma c}\int_{b-2\sigma_s}^{b+2\sigma_s} e^{-\frac{t_c^2}{2\sigma_c}}\,dt = \frac{1}{\sqrt{2\pi}}\int_{\frac{b-2\sigma_s}{\sigma_c}}^{\infty} e^{-\frac{x^2}{2}}\,dx - \frac{1}{\sqrt{2\pi}}\int_{\frac{b+2\sigma_s}{\sigma_c}}^{\infty} e^{-\frac{x^2}{2}}\,dx.$$

The following calculation steps are required:*

1. $2\sigma_s = t_s/\sqrt{2 \ln 2}$
2. $\sigma_c = t_c/2\sqrt{2 \ln 2}$
3. $x_1 = (b-2\sigma_s)/\sigma_c$
4. $x_2 = (b+2\sigma_s)/\sigma_c$
5. $Q(x_1) = \frac{1}{\sqrt{2\pi}}\int_{x_1}^{\infty} e^{-\frac{x^2}{2}}\,dx$
6. $Q(x_2) = \frac{1}{\sqrt{2\pi}}\int_{x_2}^{\infty} e^{-\frac{x^2}{2}}\,dx$
7. $I_o = Q(x_1) - Q(x_2)$
8. $A_o = I_o A_c/A_s$
9. Percentage overlap = $A_o \times 100$

where

A_s = The area of the sample peak of interest determined by electronic integration, or by the formula $A_s = h_s t_s$.

A_c = The area of the contaminant peak, determined in the same manner as A_s.

b = The distance on the chromatographic chart that separates the maxima of the two peaks.

H_s = The peak height of the sample compound of interest, measured from the average value of the baseline to the maximum of the curve.

t_s = The width of the sample peak of interest at 1/2 of peak height.

t_c = The width of the contaminant peak at 1/2 of peak height.

σ_s = The standard deviation of the sample compound of interest elution curve.

σ_c = The standard deviation of the contaminant elution curve.

$Q(x_1)$ = The integral of the normal distribution function from x_1 to infinity.

$Q(x_2)$ = The integral of the normal distribution function from x_2 to infinity.

I_o = The overlap integral.

A_o = The area overlap fraction.

*In most instances, $Q(x_2)$ is very small and may be neglected.

In judging the suitability of alternate gas chromatographic columns, or the effects of altering chromatographic conditions, one can employ the area overlap as the resolution parameter with a specific maximum permissible value.

The use of Gaussian functions to describe chromatographic elution curves is widespread. However, some elution curves are highly asymmetric. In those cases where the sample peak is followed by a contaiminant that has a leading edge that rises sharply but the curve then tails off, it may be possible to define an effective width for t_c as "twice the distance from the leading edge to a perpendicular line through the maxim of the contaminant curve, measured along a perpendicular bisection of that line."

Supplement B—Procedure for Field Auditing GC Analysis

Responsibilities of audit supervisor and analyst at the source sampling site include the following:

A. Check that audit cylinders are stored in a safe location both before and after the audit to prevent vandalism of same.

B. At the beginning and conclusion of the audit, record each cylinder number and cylinder pressure. Never analyze an audit cylinder when the pressure drops below 200 psi.

C. During the audit, the analyst is to perform a minimum of two consecutive analyses of each audit cylinder gas. The audit must be conducted to coincide with the analysis of source test samples. Normally, it will be conducted immediately after the GC calibration and prior to the sample analyses.

D. At the end of audit analyses, the audit supervisor requests the calculated concentrations from the analyst and then compares the results with the actual audit concentrations. If each measured concentration agrees with the respective actual concentration within ±10 percent, he then directs the analyst to begin the analysis of source samples. Audit supervisor judgment and/or supervisory policy determine course of action with agreement is not within ±10 percent. Where a consistent bias in excess of 10 percent is found, it may be possible to proceed with the sample analyses, with a corrective factor to be applied to the results at a later time. However, every attempt should be made to locate the cause of the discrepancy, as it may be misleading. The audit supervisor is to record each cylinder number, cylinder pressure (at the end of the audit), and all calculated concentrations. The individual being audited must not under any circumstance be told the actual audit concentrations until the calculated concentrations have been submitted to the audit supervisor.

BILLING CODE 6560-01-M

FIELD AUDIT REPORT

PART A - To be filled out by organization supplying audit cylinders

1. Organization supplying audit sample(s) and shipping address

_____

2. Audit supervisor, organization, and phone number

_____

_____

3. Shipping instructions: Name, Address, Attention

_____

_____

_____

4. Guaranteed arrival date for cylinders _____
5. Planned shipping date for cylinders _____
6. Details on audit cylinders from last analysis

		Low Conc.	High Conc.
a.	Date of last analysis	_____	_____
b.	Cylinder number	_____	_____
c.	Cylinder pressure, psi	_____	_____
d.	Audit gas(es)/balance gas	_____	_____
e.	Audit gas(es) ppm	_____	_____
f.	Cylinder construction	_____	_____

PART B - To be filled out by audit supervisor

1. Process sampled _____

_____

2. Location of audit _____

_____

3. Name of individual audited _____
4. Audit date _____
5. Audit results

		Low Conc. Cylinder	High Conc. Cylinder
a.	Cylinder number	_____	_____
b.	Cylinder pressure before audit, psi	_____	_____
c.	Cylinder pressure after audit, psi	_____	_____
d.	Measured concentration, ppm		
	Injection #1*	_____	_____
	Injection #2*	_____	_____
	Average*	_____	_____
e.	Actual audit concentration, ppm (Part A, 6e)	_____	_____
f.	Audit accuracy*		
	Low Conc. Cylinder	_____	
	High Conc. Cylinder		_____

*Percent accuracy = $\frac{\text{Measured Conc.} - \text{Actual Conc.}}{\text{Actual Conc.}} \times 100$

g. Problems detected (if any) _____

_____

_____

_____

*Results of two consecutive injections that meet the sample analysis criteria of the test method.

[FR Doc. 80-11663 Filed 4-17-80; 8:45 am]
BILLING CODE 6560-01-C

Reader Aids

Federal Register

Vol. 45, No. 77

Friday, April 18, 1980

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AGENCY PUBLICATION ON ASSIGNED DAYS OF THE WEEK

The following agencies have agreed to publish all documents on two assigned days of the week (Monday/Thursday or Tuesday/Friday). This is a voluntary program. (See OFR NOTICE FR 32914, August 6, 1976.)

Monday	Tuesday	Wednesday	Thursday	Friday
DOT/SECRETARY	USDA/ASCS		DOT/SECRETARY	USDA/ASCS
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DOT/FAA	USDA/FNS		DOT/FAA	USDA/FNS
DOT/FHWA	USDA/FSQS		DOT/FHWA	USDA/FSQS
DOT/FRA	USDA/REA		DOT/FRA	USDA/REA
DOT/NHTSA	MSPB/OPM		DOT/NHTSA	MSPB/OPM
DOT/RSPA	LABOR		DOT/RSPA	LABOR
DOT/SLSDC	HEW/FDA		DOT/SLSDC	HEW/FDA
DOT/UMTA			DOT/UMTA	
CSA			CSA	

Documents normally scheduled for publication on a day that will be a Federal holiday will be published the next work day following the holiday.

Comments on this program are still invited. Comments should be submitted to the Day-of-the-Week Program Coordinator. Office of the Federal Register, National Archives and Records Service, General Services Administration, Washington, D.C. 20408

REMINDERS

The "reminders" below identify documents that appeared in issues of the **Federal Register** 15 days or more ago. Inclusion or exclusion from this list has no legal significance.

Rules Going Into Effect Today

INTERIOR DEPARTMENT

Fish and Wildlife Service—

17862 3–19–80 / Seizure and forfeiture procedures

NATIONAL CREDIT UNION ADMINISTRATION

17565 3–19–80 / Availability of information; public observation of Board meetings; Government in the Sunshine Act

17568 3–19–80 / Rules of Board procedure

Rules Going Into Effect April 19, 1980

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Fish and Wildlife Service—

18009 3–20–80 / Listing with endangered status for five species of foreign reptiles

List of Public Laws

Note: No public bills which have become law were received by the Office of the Federal Register for inclusion in today's **List of Public Laws.**

Last Listing April 16, 1980

Just Released

CODE OF FEDERAL REGULATIONS

(Revised as of October 1, 1979)

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